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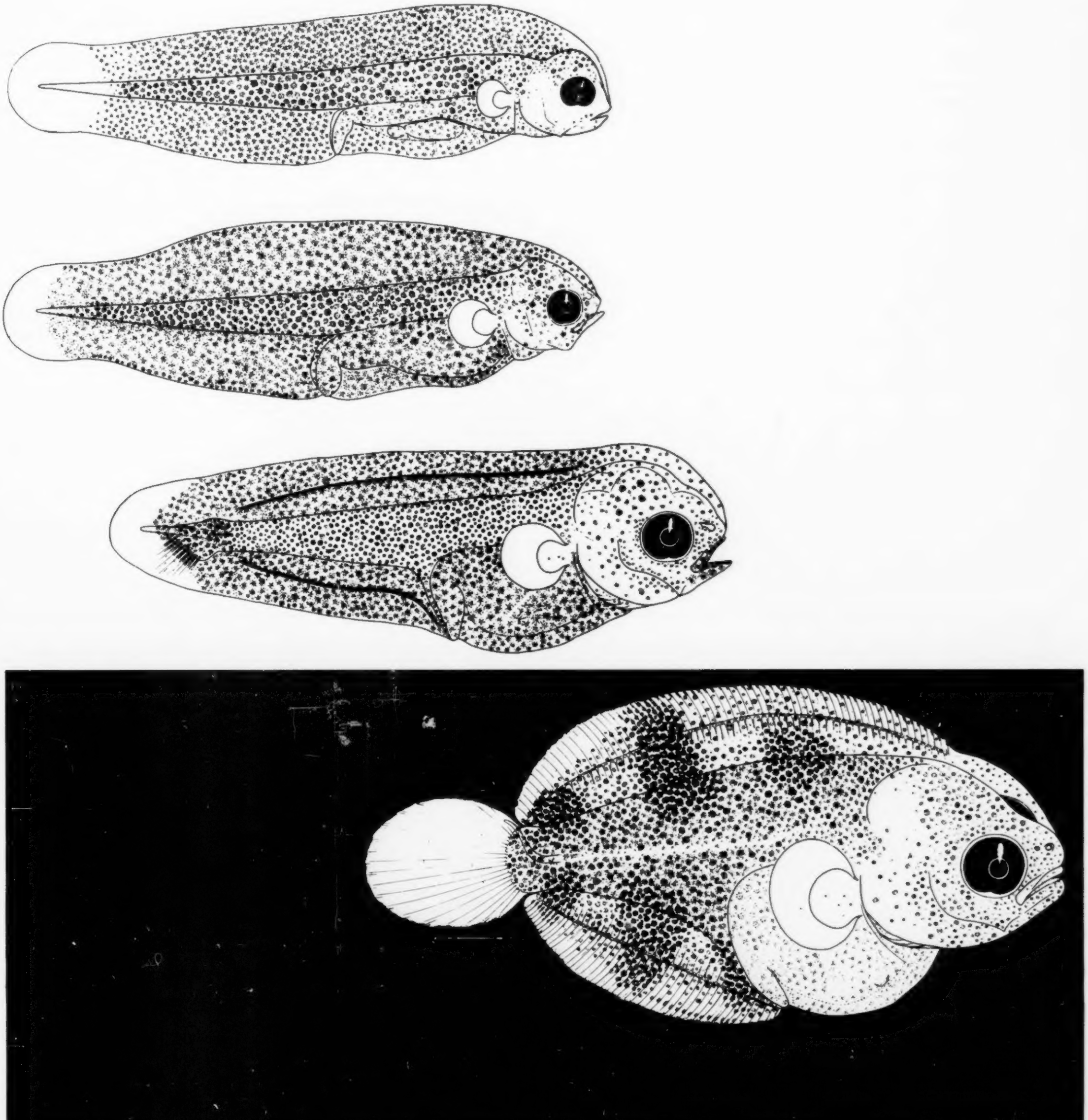

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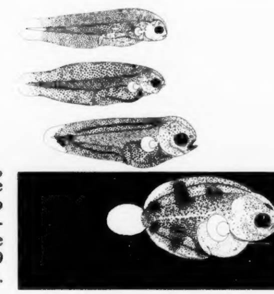

On the cover: Curlfin sole, *Pleuronichthys decurrens*, larvae from the new "Laboratory guide to early life history stages of northeast Pacific fishes," by A. C. Matarese et al. NOAA Technical Report NMFS 80:619 (available from NTIS, Springfield, Virginia).

Articles *51(1), 1989*

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Economic and Trade Strategies in World Fisheries

Robert A. Siegel and Richard S. Johnston, Editors

Introduction

This special section of the *Marine Fisheries Review* contains the edited proceedings of a symposium held on 16 September 1987 at the annual meetings of the American Fisheries Society in Winston-Salem, N.C. The symposium was sponsored by the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration, and the International Institute of Fisheries Economics and Trade. The aim of this session was to provide an overview of several international trade issues that affect the development of fisheries economic policy. Thus, the general areas of discussion included: The role of fisheries in the U.S. balance of trade, current negotiations on fisheries trade and tariffs, and U.S. and foreign economic trade strategies and policies.

In the past 10 years, there has been a significant increase in world trade in fishery products. Between 1976 and 1985, world catches grew from 69 million metric tons to 85 million metric tons, while the share of production that entered international trade rose from 29 percent to 35 percent. Over this period, developing countries have played a larger role in the growth of world fisheries trade. Their share of the volume of world exports of fishery commodities increased from 33 percent to 42 percent. These figures suggest a greater interdependence among countries in world fisheries trade.

The general theme of the papers in this session is how the international distribution of fishing rights are changing along with the impacts on global markets. A major factoı causing a change in fishing rights is extended jurisdiction.

The paper by Gordon R. Munro discusses the analytical framework used by economists to evaluate extended jurisdiction resource management issues. The paper focuses on the benefits of extended jurisdiction arrangements for coastal states and distant water fishing nations (DWFN's). He evaluates several cooperative arrangements where the participation between the domestic fleet and DWFN's depends on their comparative advantage in harvesting and processing fishery resources. Munro also provides a general discussion of the arguments for and against phasing out distant-water fishing fleets and of the potential licensing/access fee arrangements. He suggests that a principal-agent framework may reveal elements of the arrangements that govern DWFN's participation in a coastal state's fisheries. Thus, a coastal state has several issues to consider in determining the optimal mix of access terms and conditions with DWFN's.

The paper by Lipton and Siegel examines some of the factors that affect U.S. trade in seafood products. One of the major goals of the U.S. Department of Commerce is to reduce the U.S. trade deficit. Seafood products are a significant contributor to the trade imbalance. In 1986, the United States had a trade deficit in fishery products of $6.2 billion.

The paper indicates that U.S. demand for seafood products will continue to increase. Domestic fisheries in the United States will not be able to supply the growing markets for shellfish, salmon, and certain groundfish. Thus, imports are likely to increase and worsen the trade deficit, unless depressed domestic stocks in U.S. fisheries are rebuilt, substitutes are developed for traditional fishery products, or aquaculture becomes profitable.

The paper by Larry Snead reviews the evolution of U.S. international fisheries policy as it relates to access rights. Passage of the Magnuson Fishery Conservation and Management Act of 1976 (MFCMA) resulted in a radical change in the pattern of distant-water and domestic fishing operations off the U.S. coast. Similarly, the extensions of 200-mile exclusive fishing jurisdictions by other nations has affected U.S. distant-water fisheries.

In recent years, allocations to foreign nations have declined from

more than 2 million metric tons in 1977 to less than 200,000 metric tons in 1987. With the phase-out of foreign fishing, increased emphasis is being given to access to resources in other countries' waters, the problems surrounding straddling and transboundary stocks, and fisheries trade. The United States is working out solutions to these difficult issues through international negotiations and cooperation with other countries.

The change in ownership of fish stocks from international commons to the coastal state has resulted in "resource winners and losers." Giulio Pontecorvo examines whether the "transfer of assets" has resulted in income gains in three neighboring countries: The United States, Canada, and Mexico. Pontecorvo emphasizes that the existing data base on factors of production such as capital and labor is quite limited. This complicates the analysis and makes the estimates somewhat tentative. Nevertheless, he indicates that the three countries gained substantial benefits from extended jurisdiction. However, with more labor and capital present in the fishery, both inefficiencies and increased economic risk may have resulted.

Terry and Queirolo provide an overview of the international trade issues that affect the management of the groundfish resources off the coast of Alaska. The stocks of traditional species (salmon, crab, and halibut) are unique in that the potential product supply is large enough to significantly affect market prices. An important trade issue is whether the United States can develop the processing capacity—both at-sea and shoreside—to compete profitably in world groundfish markets. Another issue is the allocation of groundfish between domestic and foreign fishing fleets.

These issues are analyzed in the context of world markets. In particular, Terry and Queirolo examine the size of the major markets and trace the price linkages. They argue that for cod, prices are determined in international markets and that, therefore, the U.S. and Japan take these prices as "given." Furthermore, the authors consider how trade patterns will be affected by a growing U.S. dominance of the Alaska groundfish fishery and suggest that price-cost relationships in the domestic Pacific cod fishery are likely to be less favorable in the future than they are now.

The paper by Queirolo and Johnston takes a broad look at new patterns of international trade and management regimes that have resulted from extended jurisdiction. They develop a conceptual model that examines the production possibilities of coastal states that have declared an extended jurisdiction zone and countries that have had their distant water fishing fleets excluded from their traditional fishing grounds.

The authors extend the analysis of the economic impacts of extended jurisdiction by examining how coastal states and distant-water fishing fleets can both benefit from cooperative harvesting and processing agreements. Of particular interest is the discussion of the Americanization of U.S. fisheries and the U.S. push to become a major exporter of fishery products. The paper reviews the progress of an international cooperative study to investigate supply and demand relationships in world groundfish markets.

Coastal States and Distant-water Fishing Nation Relations: An Economist's Perspective

GORDON R. MUNRO

Introduction

The widespread implementation of Extended Fisheries Jurisdiction (EFJ) has confronted coastal states with several resource management problems. One of these consists of the economic relations, if any, that the coastal state should establish with distant-water fishing nations (DWFN's) seeking access to the coastal state's 200-mile zone.

Several of the other papers presented here deal with specific aspects of the issue. This paper, on the other hand, will concern itself with the question of the analytical framework to be used by economists in studying this issue. It will offer some suggestions with respect to possible components of the framework.

In doing so, the paper will restrict itself to the coastal state's perspective of EFJ and the management issues arising therefrom. It goes without saying, of course, that an enlightened coastal state will attempt to acquaint itself with the DWFN view of the world.

Coastal State Obligations and Coastal State Beneficiaries Under EFJ

Before one can discuss appropriate analytical frameworks, it is necessary to deal with two prior questions. The first is concerned with the obligations of coastal states to DWFN's under the U.N. Law of the Sea Convention and the significance of these obligations. The second is concerned with the designated beneficiaries of EFJ within the coastal state[1].

With regard to the first question, the Law of the Sea Convention, which arose from the U.N. Third Conference on the Law of the Sea, has yet to be signed, let alone ratified, by several important maritime nations. The Convention may never achieve the status of international treaty law. Nonetheless, it now seems to be generally accepted that Part V of the Convention on the Exclusive Economic Zone (United Nations, 1982) has achieved the status of customary international law (Fleischer, 1984) and has come to provide most, if not all, of the "rules of the game" under EFJ. Even the United States, the most prominent of the nonsigners of the Convention, has accepted the concept of the Exclusive Economic Zone (EEZ).[2] Hence, when one considers coastal state obligations to DWFN's, as set forth in the Convention, there is little question as to the significance of these obligations.

Within Part V of the Convention, the articles of greatest relevance to the coastal state-DWFN issue are Articles 56, 61, 62, 63 and 64. The first three are of prime importance.

Article 56 accords the coastal state "sovereign rights for the purpose of exploring and exploiting, conserving and managing. . ." living (as well as nonliving) resources within the state's EEZ (United Nations, 1982). As such, the Article, to all intents and purposes, grants the coastal state property rights over the fishery resources within its 200-mile zone. The one possible exception consists of the highly migratory species (i.e., tunas), about which there has been great controversy. This will be commented on later.

An apparent major qualification to the coastal state's fishery property rights, a qualification of direct relevance to coastal state obligations to DWFN's, is to be found in Article 62. Article 62 contains the "surplus principle," which can be stated briefly as follows. For each fishery within its 200-mile zone, the coastal state is to determine its harvesting capacity in relation to the total allowable catch (TAC) set for the fishery. Where the harvesting capacity falls short of the TAC, a surplus is deemed to exist. Article 62 calls upon the coastal state to give "other states" (DWFN's in particular) access to the surplus (United Nations, 1982).

I have argued many times (e.g., Munro, 1985a) that, from an economic standpoint at least, the surplus principle is largely empty. Under Article 61, the coastal state is given unambiguous power to set the TAC's for the relevant fisheries. Hence, there is no legal reason why a coastal state could not eliminate surpluses through adjustments of the TAC's.[3] More impor-

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[1] To use some of the economist's jargon, when we consider relevant coastal-state fisheries and the economic benefits flowing therefrom, we must ask whose objective functional is to be maximized through time.

[2] A Presidential proclamation in March 1983 announced the adherence of the United States to the EEZ concept.

[3] It is true that, if the coastal state sets TAC's which the international community deems to be outrageously low, the coastal state may well encounter severe enforcement difficulties.

tantly, Article 62 gives the coastal state very broad powers in imposing terms and conditions of access upon those states seeking access to the "surpluses." In no sense whatsoever is the coastal state expected to give DWFN's free access to the "surpluses." Indeed, with a modest amount of imagination, a coastal state could impose a set of terms and conditions that would discourage all DWFN's seeking access to the aforementioned surpluses.[4]

Article 62 does call upon coastal states wishing to remove DWFN fleets from their zones to allow for a phase-out period to avoid undue dislocation to the DWFN's. Beyond that, however, it is difficult not to accept the following conclusion of William Burke of the University of Washington and specialist on the Law of the Sea: ". . . the coastal state is given substantially complete discretion to manage the fisheries for its own exclusive interests, however, narrowly and selfishly conceived they might be" (Burke, 1983: 46).

The one disputed exception to coastal state property rights, highly migratory species, is covered by Articles 63 and 64. Coastal states are admonished to cooperate with neighboring coastal states and with DWFN's, where appropriate, in the conservation of these resources. One DWFN, the United States, pressed the need for cooperation to the point of arguing that coastal states should not have management control over, let alone property rights to, highly migratory species. Rather, such resources should be seen as international common property that properly should be managed by international bodies having full DWFN participation.

This position led the United States into conflict with the Pacific Island Nations, a conflict which was eventually resolved through treaty negotiations. A treaty was signed in April 1987, and at the time of writing awaits ratification. The outlook for ratification is excellent.

Though not a lawyer, I would argue that, by signing the treaty, the United States has gone a very long way in conceding that coastal states do indeed have property rights to highly migratory species. While the treaty provisions apply only to U.S. fisheries relations with a limited number of coastal states, it is difficult to believe that these provisions will not in time influence American relations with all coastal states having highly migratory species that pass through their EEZ's.

Thus, coastal state property rights to fishery resources can be seen as being more or less complete. Hence we conclude that the "surplus principle" is largely devoid of economic content. From this it follows that, if there is to be a DWFN presence in a given coastal state's EEZ over the long run, it will be because it is in the selfish interest of the coastal state for there to be such a presence.

To determine whether it will be in the selfish interest of the coastal state for there to be a DWFN presence in its zone, we must answer the second prior question, namely, "Whose benefits from the relevant fisheries are to be maximized through time?" The obvious response is that the coastal state will simply maximize its own benefits from the relevant fisheries.

Such a response is inadequate, not because the coastal state should be concerned with the needs of others, but rather because the response is too vague. Should the response be taken to mean that the benefits of the nation as a whole from the fisheries are to be maximized? Or does the response really mean that the benefits of the fishing regions of the country are to be maximized? Alternatively, is the real concern with the benefits of the domestic fishing industry from the fisheries? If the fishing industry benefits are to be maximized, then should the harvesting or processing sector be favored?

Until this set of questions is dealt with, it is not really possible to analyze sensibly the issue of coastal state-DWFN economic relations. There is, for example, no guarantee whatsoever that policies designed to maximize the returns from the relevant fisheries to the domestic fishing industry will also maximize the returns from these fisheries to the nation as a whole.

If the question of the object of fisheries management is left unresolved, policies pertaining to the coastal state's economic relations with DWFN's are likely to be confused, if not destructive.

Most coastal states, of which I am aware, claim that their objective in managing fisheries within their EEZ's is to maximize the national benefits from these fisheries through time. It shall, therefore, be assumed in the discussion to follow that the coastal state's fisheries management objective is in fact that of maximizing the flow of national benefits from the fisheries. As a first approximation, we can measure these benefits in terms of net contributions to the coastal state's national income.

It needs to be stressed, however, that if the real objective of fisheries management is other than that of maximizing the national benefits from the fisheries, what follows may require drastic modification.

Potential Benefits of Long-Term Coastal State-DWFN Arrangements and Infant Industries

We come now to consider the potential benefits to a coastal state from long-term arrangements with DWFN's, stressing the adjectives "potential" and "long-term." If we are concerned only with short-term, essentially phase out, types of arrangements, the interest provided by the arrangements is extremely limited. Potential is emphasized because if the benefits are positive, there is no assurance that they will be realized. Such benefits can easily be dissipated through poorly constructed sets of access terms and conditions. Later I discuss the question of access terms and conditions.

It is not too great an exaggeration to say that, at the dawn of EFJ, the gen-

[4]Article 300 of the Convention, the "Good Faith and Abuse of Rights" article, does, according to many legal authorities, imply that the coastal cannot impose terms and conditions of access which are clearly designed to deny DWFN's access (Burke, 1983). Imaginatively designed terms and conditions, of course, could effectively bar DWFN's without giving them a basis upon which to invoke Article 300.

eral view among coastal states was that the benefits to them of a long-term DWFN presence in their zones were seen to be nonexistent, if not negative. It seemed obvious that, if a coastal state were to capture the full economic benefits from its EEZ, it should remove DWFN fleets from 200-mile zone with all possible speed and replace their activities with domestic harvesting and processing.

While this view is still prevalent, we do now have cases in which coastal states are making explicit references to long-term arrangements with DWFN's or are prepared to concede that such long-term arrangements are a distinct possibility. I have argued on several occasions that there are sound economic reasons why such long-term arrangements might be considered, reasons which can be derived from an application of rather elementary international economics (Munro, 1981, 1985a, b). The tools of international economics also prove to be very useful in analyzing the arguments against such long-term arrangements. I shall review the earlier applications of international economics to coastal state-DWFN arrangements and introduce some important qualifications and additions ignored in the earlier treatments.

During the Second International Institute of Fisheries Economics and Trade Conference, New Zealand economists, Kerr and Sharp (1985:268) wrote that "Co-operative agreements provide coastal states with an opportunity for developing their exclusive economic zones, and foreign partners with an opportunity to utilize a resource. The advantages of such cooperation may be found in differences that exist between the partners with respect to endowments of: information . . . technique, capital . . . natural resources."

If we were to restate this argument in the language of international economics, we would say that such cooperative arrangements may make economic sense for a coastal state because the DWFN('s) possess a comparative advantage in the provison of certain harvesting and/or processing services.

One can think of the coastal state "hiring" DWFN's to provide harvesting/processing services, or alternatively, one can think of the coastal state "importing" such DWFN services. Expressed in this fashion, the argument on behalf of long-term coastal state-DWFN arrangements, as seen from the coastal state perspective, is simply a variant of the argument for free trade.

Thus, suppose that in a particular fishery within a coastal state's EEZ, DWFN's possess a comparative advantage in harvesting the resource vis-a-vis domestic harvesters. A free trade type of argument would state that the coastal state should avail itself of the cheaper DWFN harvesting services.The argument would continue that by so doing the coastal state would enhance the fishery's contribution to its national income. Whether such an arrangement should be of short or long term would depend upon whether the comparative advantage of the DWFN proves to be of short or long term.

If the DWFN's possess a comparative advantage in processing, rather than harvesting, the argument is less obvious. Nonetheless, it does not require much skill as an economist to demonstrate the argument's validity in this case. One can indeed maintain that the fishery's contribution to the coastal state's national income will be enhanced if the coastal state avails itself of the DWFN's processing services.

It can further be maintained that comparative advantage should as well dictate the structure of the coastal state-DWFN arrangement. At one extreme, the DWFN's might exhibit a comparative disadvantage in the provision of all relevant harvesting and processing services. Then there should be no arrangements with DWFN's based on the fishery in question.

At the other extreme, DWFN's may possess a comparative advantage in all aspects of harvesting/processing, in which case a "fee" fishing type of arrangement would be appropriate. The DWFN fleets would both harvest the resource and process the catch in return for a "fee" (e.g., a tax on catch or on effort). Between those extremes, it might be found that comparative advantage dictated a joint venture type of arrangement in which some of the harvesting/processing services would be provided by the DWFN fleets and part by coastal state entities.

Many factors can give rise to DWFN comparative advantages. No attempt will be made to discuss them here as they are analyzed in detail elsewhere (e.g., Munro, 1985a). Examples are relative factor endowments or seasonality conditions.

In my previous papers on this topic, the unfortunate impression was created that the dictates of comparative advantage will lead to an either/or result. That is, comparative advantage would result in a particular harvesting or processing activity being carried out exclusively by domestic entities or exclusively by DWFN fleets.

This is the equivalent of complete specialization in international economics. Every student of this branch of economics is taught that, while complete specialization is possible and observable, it is not the usual outcome. More commonly, as specialization begins to take place, relative foreign and domestic cost change with the consequence that incomplete specialization occurs.

A particular country may have a clear comparative disadvantage in the production of commodity X. Nonetheless, it might be found that if the country permitted the unhindered importation of commodity X, then the country would still have a small, but entirely viable, X industry.

In the context of fisheries, incomplete specialization could be illustrated as follows. In a particular fishery within a coastal state's EEZ it is found that the DWFN's have an unequivocal comparative advantage in the provision of all harvesting and processing services. The coastal state places no hindrances on the establishment of cooperative arrangements with the DWFN's. Nonetheless, there emerges over time a small, but fully competitive, domestic industry based on the fishery and engaged in both harvesting and processing operations. Optimal

policy would result in the balance between domestic and DWFN operations being such that the fishery's contribution to the coastal state's national income was maximized.

An example is provided by the Pacific Island Nations. Small domestic tuna industries exist. It is anticipated that such domestic industries will expand and multiply over time. Yet it is also anticipated that DWFN's will play a major role in the Island Nations' tuna fisheries for a very long time indeed (Clark, 1985).

The arguments on behalf of long-term arrangements with DWFN's are straightforward. Those against, on the other hand, are complex and the source of considerable controversy. There is no controversy, let it be noted, however, in those instances in which harvesting/processing comparative advantages clearly lie with the coastal state. There would then be general agreement within the coastal state that no arrangements with DWFN's, other than phase-out arrangements, would be justifiable.

Rather, controversy arises in those instances in which the comparative advantage in harvesting and/or processing clearly lies with the DWFN(s). In such instances, the arguments against long-term arrangements with DWFN's are, upon inspection, seen to be really arguments for the protection of the domestic harvesting or processing sector. Thus, the controversy which arises can be seen as a free trade vs. protection argument. The relevance of international economics to an analysis of the controversy is obvious.

I might note in passing that the instruments of protection seldom, if ever, take the textbook form of tariffs and quotas. Rather, the protection is to be found in the terms and conditions of access. An example, would be the discriminatory harvest allocation system employed both in Canada and the United States.[5]

[5]The allocation system, about which more will be said later, operates as follows: A TAC is set for a particular fishery. Wholly domestic operations have first call upon the TAC. If there is a residual, joint-venture operations then have a claim. If there is still a residual, it is allocated to wholly DWFN operations.

As is noted in every standard text in international economics, the argument for free trade is essentially a global argument. Free trade, it is alleged, will lead to an optimal allocation of world resources from which all stand to benefit. Most trade economists will concede, however, that limited protection may benefit individual countries. Since our concern is with individual coastal states, not the world at large, the arguments for protecting domestic harvesters and processors cannot be dismissed out of hand.

The aforementioned economists, who concede that protection may be valid from the perspective of an individual country, proceed to divide the arguments for protection into two categories: Legitimate and illegitimate. The test of legitimacy lies in whether the protection being prescribed will lead to an enhancement of the country's national income. Illegitimate arguments for protection, if accepted, may well result in certain industries, groups, or regions benefiting. The benefits of protection will, however, come at the expense of the rest of the country.

So called illegitimate arguments for protection, while being rejected by most economists, often have immense political appeal. This is no less true in the area of fisheries and EFJ than it is in ordinary commodity trade. Let one example suffice. For want of a better term, I shall refer to the argument as the "value added" argument.

As a first approximation, the contribution of a domestic industry to the country's national income is equal to its value added.[6] Now suppose that a country both produces and imports commodity Y. The domestic producers of Y argue for protection on the grounds that, if imports are curbed, the domestic Y industry's value added will expand. Thus the industry's contribution to the national income will be increased. Without protection, value added will continue to be lost to foreigners.

[6]Value added can be measured by summing the industry's profits and its payments to the owners of "primary" inputs (e.g. labor, capital, natural resources) employed by the industry.

In the context of fisheries and EFJ, the argument tends to appear in the following fashion. If the existing DWFN fleets operating in the EEZ are forced out by appropriate access terms and conditions, they will be replaced by domestic harvestors/processors. Thus the domestic fishing industry's value added and the industry's contribution to the national income will increase. If the foreigners are permitted to continue unhindered, value added will go on being lost to the foreigners.[7]

The flaw in the argument is easy to detect and should be obvious to any competent student in a principles course in economics. If the domestic industry in question is protected, its value added per period of time can indeed be expected to increase. However, the labor, capital, and natural resources giving rise to this increased value added will be drawn from other activities in the economy.[8] Hence value added in other parts of the economy will fall. The net contribution of protection to national income could well be negative.

Of the legitimate arguments for protection, the one with greatest relevance to the coastal state-DWFN arrangement debate is also the most famous of such arguments. It is the infant industry argument, which is in reality an argument for temporary protection. It rests upon the premise that the country has a latent comparative advantage in a particular activity.

The argument runs that, while the country has a latent comparative advantage in the activity, newly established domestic firms attempting to exploit the advantage cannot survive in

[7]A related arugment arising in the case of "fee" fishing runs as follows. DWFN's pay the coastal state an amount equal to some small percentage of the gross commercial value of the catch, say 5 percent. If the DWFN's were replaced by domestic harvesters and processors, 100 percent, rather than 5 percent, of the benefits would accrue to the coastal state. Presumably what the supporters of the argument have in mind is that the full value added will be captured by the coastal state, rather than the DWFN's. The value added is, of course, significantly less than 100 percent of the gross commercial value of the catch.

[8]Unless these inputs would otherwise have been unemployed. Then the argument for protection would become the quasi-legitimate employment argument for protection.

the face of competition from well established foreign rivals. The infant domestic firms should, therefore, be protected until they have gone through the necessary learning stage. Once the firms have completed this stage, they will be fully competitive and the country's comparative advantage will stand revealed. The walls of protection can then be dismantled.

The argument is particularly relevant to EFJ because EFJ has not led to a situation in which existing domestic harvesting/processing activities are endangered by competition from DWFN's. Rather it has led to a situation in which domestic harvestors/processors wish to undertake new activities, but doubt they could survive in face of competition from well entrenched DWFN rivals.

In previous papers (e.g., Munro, 1985a) I have stated that the infant industry argument applied to coastal states and EFJ might run as follows:

"Prior to E.F.J. international fisheries, subsequently to be encompassed by the [coastal] state's EEZ, held little or no interest to the coastal state fishing industry. The fisheries may have required capital intensive operations with specialized gear/and or vessels, while the fisheries themselves were subject to non-existent or weak management. Thus the investment required was deemed to be excessively risky. The risk for distant-water nations, whose fleets moved throughout the world, was far less.

"Now that the fisheries are under coastal state management, the argument continues, the fisheries are of much greater interest to the domestic industry. Domestic harvestors and/or processors cannot, however, compete unprotected against well established distant-water fleets. If protection for the coastal state industry were forthcoming and maintained until the domestic fishing industry had passed through the learning and development phase, then the coastal state's comparative advantage, now latent, would be revealed" (Munro, 1985a:9).

Both the United States and Canada provide clear examples of the application of this argument. One such example is provided by the groundfisheries off Alaska. The fisheries have, since the late 1970's, been dominated by joint ventures in which U.S. trawlers harvest the resource and deliver the catch to foreign processing vessels. There is now, however, rising interest in U.S.-owned processing vessels. Protection is demanded by the owners of these vessels. The infant industry argument is brought to bear.

Indeed, in a statement by the Alaska Factory Trawler Association, it was maintained that " . . .we are a fragile 'infant' industry." The statement then went on to insist on more rigorous measures to remove the foreign rivals from the U.S. EEZ.[9] It can be asserted without fear of contradiction that a lengthy search would not be required to find additional infant industry examples among other coastal states.

While the infant industry argument is certainly legitimate, there are counter arguments which need to be taken into account. The standard ones are that: 1) It is very difficult to determine a priori which infants do in fact have reasonable prospects of achieving maturity, 2) in those instances in which the infants do achieve maturity, one still has to weigh the costs of protection against the benefits from bringing the industry to maturity and 3) even when the infant does reach maturity and when the potential net benefits of protection prove to be positive, it becomes politically very difficult to remove the protective barriers once such a removal is called for.

Thus the risk exists in applying the infant industry argument that the latent comparative advantage will prove to be nonexistent. The infant is either terminated, often painfully, or is allowed to linger on—a permanent burden to the economy. Alternatively, the industry may grow to maturity, but exert sufficient political pressure to maintain the protection indefinitely at the expense of the rest of the economy.

In the case of fisheries, there is yet another problem with the infant industry argument, which has become particularly visible in Alaska. This is the fact that, within a given EEZ fishery, there may be two "infants" to contend with, a harvesting sector "infant" and a processing sector "infant." Giving support to one "infant" can easily come at the expense at the other. Thus, for example, granting protection to the processing sector "infant" . . . might well damage the harvesting sector "infant," which might achieve most rapid growth by being permitted to enter into joint ventures with foreign offshore processors. (Alverson, 1987, presents examples of where this problem has emerged.)

There is a second legitimate argument for protection that proves to be relevant to fisheries and which, until recently, the author believed wrongly to have no relevance at all. This is the "terms of trade" argument. The argument states that by introducing barriers to import or export flows, a country may be able to shift the terms of trade in its favor. The argument rests critically upon the country having some degree of monopoly and monopsony power in the sale of exports and purchase of import products respectively and rests critically as well upon the assurance that the country will not be subject to extensive retaliation by its trading partners.

The application of this argument to fisheries, of which this author is aware, appears in the United States in the guise of the "market void theory." It is maintained that if DWFN fleets as harvesters and processors are denied access to the Alaskan groundfisheries, then a "void" will be created in foreign groundfish markets. The consequence will be that prices of U.S.-harvested and processed groundfish products will rise. The debate over this argument has focussed on the degree of U.S. monopoly power in this area (Pereyra, 1986).

There is another aspect of protectionism, outside of the arguments for and against protectionism, which is relevant, and which has largely been

[9]Testimony of E. D. Evans, representing the Alaska Factory Trawler Association, cited in Pereyra 1986. For a discussion of the application of the infant industry argument in Canada see Munro (1985b).

ignored in the literature. This is the concept of "effective," as opposed to nominal, protection. When a domestic industry is protected, the protection does, in fact, apply to the industry's value added. It, therefore, becomes important to know whether the costs of the intermediate inputs are influenced by protection. If such costs are greatly increased by protection, the "effective" protection enjoyed by the industry could in fact be negative.

Thus in the case of fisheries a domestic harvesting or processing sector may appear to be uncompetitive with respect to DWFN's only because the costs of intermediate inputs are inflated by protection. For example, suppose that domestic fishermen and offshore processors were compelled to purchase their vessels from heavily protected, high-cost domestic shipyards, while DWFN fleet owners were able to purchase their vessels on the world market. In assessing the degree of protection actually enjoyed by the domestic fishing industry, it would be essential to acknowledge the inflated capital costs of the industry.

If one were asked to provide examples of protectionism under EFJ, it would be necessary to look no further than North America. Both the United States and Canada follow essentially the same policy, which is one of high protectionism. In both countries, protectionism appears, as indicated earlier, through the harvest allocation system. First preference is given to operations involving domestic harvesting and processing, second preference to joint ventures, and last preference to foreign "fee" fishing.

Off Canada's Atlantic coast, where most of Canada's gains from EFJ lie, DWFN participation in Canada's EEZ fisheries has steadily dwindled and in time will likely approach zero. In the groundfisheries off Alaska, foreign "fee" fishing, or directed fishing, declined rapidly to be replaced by joint ventures (Pereyra, 1986). Reference has been made to the increasing interest in U.S. owned and operated factory trawlers. It is now being argued that this interest may well lead to the phasing out of joint ventures within a decade (Alverson, 1987).

While it is easy to find examples of protectionism in coastal state-DWFN relations, it is more of a challenge to find cases in which something approaching a free trade policy is adopted. No coastal state, of course, follows a pure "free trade" policy.

Nonetheless, while the search is challenging, examples can be found. There is one case which we have already raised, the Pacific Island Nations which collectively lay claim to high-valued and immense tuna resources. While some of the Island Nations have infant tuna industries, which they intend to foster, it also remains true that they have established, with formidable skill, long-term agreements with DWFN's (Clark, 1985). It is also clear that their stated object of management is clearly that of maximizing national benefits from the fisheries (Kotobalavu, 1987).

It can be argued that the Pacific Island Nations have little choice, because they lack and can expect to lack, the capital to exploit fully their tuna fisheries. This can be debated. The second example, however, is one in which the coastal state clearly could in time exploit the relevant fisheries with fully domestic harvesting and processing operations if it so desired. The example is New Zealand.

New Zealand instituted an EEZ in 1978. The most important species acquired were demersal species such as the high valued orange roughy. After several years of experimentation and uncertainty with respect to long-term fisheries policy, there was implemented in 1982 a deep-water trawl policy based on individual transferable company quotas.

Companies acquiring these quotas are required to have 35 percent of the harvests arising form these quotas processed in New Zealand. Beyond this, however, the companies can exploit the quotas as they see fit. If a company chooses to employ its domestic harvesting vessels and processing capacity, it may do so. If it chooses to employ foreign vessels through charter for harvesting and/or processing, it may also do so. The only restrictions are that charter fees are to be expressed in cash rather than kind and that prices received from foreign vessels are to be realistic market prices (Major, 1985; Clark and Duncan[10]).

The advantages of the scheme were and are, first, that aside from the 35 percent rule, it gives comparative advantage full reign. Secondly, the scheme is such that, once in place, it proved to be highly acceptable to the industry. Under this approach, the company quota holder which follows the dictates of comparative advantage enjoys higher profits.

It should be added in passing that part of the resource rent is garnered for public purse. The government enjoys part of the return on the fisheries through the income tax, but also through a per tonne royalty which varies according to species (Major, 1985).

Analyzing Terms and Conditions of Access

The discussion of comparative advantage and of free trade vs. protection is set in terms of the potential benefits to coastal states from long-term arrangements with DWFN's. The existence of such potential benefits provides no guarantee, however, that the benefits will in fact be realized. As suggested earlier, the potential can be easily lost if the terms and conditions of access which govern DWFN participation in the coastal state's fisheries are badly designed. Let two examples suffice.

First, suppose that the coastal state enters into "fee" fishing arrangements, but then binds itself to a policy of collecting fees only for the purpose of covering administrative and surveillance costs. In essence, this is the equivalent of willfully overpaying foreigners for harvesting and processing services. Hence, the returns to coastal state from the arrangements will be far below the potential.

[10]Clark, J. N., and A. J. Duncan. 1986. New Zealand's fisheries management policies—past, present, and future: The implementation of an ITQ-based management system. New Zealand Ministry of Agriculture and Fisheries, Wellington, unpubl. rep.

Secondly, suppose that the terms and conditions of access tolerate, or indeed encourage, wholesale cheating by the foreign fleets. The collapse of the arrangements would then be all but assured.

In deciding how to analyze the design (from the coastal state's perspective) of the optimal set of terms and conditions of access, it is important to consider the nature of the relationship between the coastal state and its DWFN partner(s). When two neighboring coastal states negotiate over the management of a shared fishery resource, it is reasonable to think of the relationship as being one that is more or less between equals. By way of contrast, when a coastal state enters into negotiations with a DWFN, the relationship is distinctly hierarchical in nature.

Under Part V of the Law of the Sea Convention, the coastal state has clear property rights to the relevant fishery resources. I argued earlier that the so called "surplus principle" is largely empty and that ambiguities over highly migratory species are being resolved in the coastal states' favor. To all intents and purposes, the coastal state can grant, or refuse to grant, access rights to DWFN's as it sees fit.

In discussing the potential benefits of coastal state-DWFN arrangements, I wrote in terms of the coastal state "importing" the harvesting/processing services of DWFN fleets. I said as well that one can just as easily talk of the coastal state "hiring" the DWFN fleets to perform harvesting/processing services.

In an ideal world, as seen from the perspective of the coastal state, the DWFN "hireling" would be subject to the absolute control of the coastal state. The DWFN fleets would not merely refrain from poaching, they would follow, with precision, a harvesting profile through time dictated by the coastal state. The aforementioned terms and conditions would be orders and requirements to be followed and observed without question.

The real world is, of course, never ideal. The coastal state cannot exercise perfect control over the DWFN "hirelings." In particular, it cannot exercise perfect control over the DWFN's harvesting policies. It may be able to prevent DWFN fleets from harvesting beyond certain limits, but it cannot compel the fleets to increase their harvesting if they are underexploiting the resources from the coastal state's point of view. Perfect control over DWFN fleets is too difficult, or more to the point, too costly to achieve. Thus, the terms and conditons of access should be viewed, not as a set of orders, but rather as a set of incentives designed to persuade the DWFN fleets to act in a manner which the coastal state deems to be satisfactory, if not optimal.

The implication of the hierarchical coastal state-DWFN relationship and the typical coastal state's inability to exercise absolute control over DWFN fleets is that the appropriate analytical framework may be found in what has come to be known as principal-agent analysis.

In such analysis, a principal is seen to acquire the services of an agent or agents. The agent performs certain tasks that will yield benefits to the principal. The principal finds it too costly to exercise absolute control over the agent. Rather the principal must content itself with establishing an incentive system for the agent, which contains within it a reward function. It is generally assumed that, over the course of the relationship, the agent must, if he is to perform, enjoy some minimum return which in turn may be determined by market forces or through bargaining.

Once the incentive system is in place, the agent, will proceed to act in a manner to maximize its own benefits or gains. The principal will enjoy the total benefits produced by the agent's actions minus the benefits accruing to the agent. The principal's objective then is to choose an incentive scheme that will maximize its benefits, given that the agent has some freedom of action and is subject to the condition that the benefits accruing to the agent must not be less than some minimum. (See Clarke and Munro, 1987, for a description of the principal-agent paradigm.)

An example of the application of principal-agent analysis, which is suggestive of the fisheries case, is to be found in the study of sharecropping (e.g., Hurwicz and Shapiro, 1978). The landlord, as owner of the land, is the principal. The tenant farmers, to whom he grants access to his land, are the agents. The landlord's return from the land is dependent in part upon the abundance of crops raised by the tenant farmers. The tenants have considerable freedom of action. The problem faced by landlord as principal is to design an incentive scheme, e.g. a crop sharing formula, that will maximize his returns, given that the tenants have some freedom of action and given that they will not act unless they are guaranteed some minimum return.

In the case of fisheries and EFJ, the coastal state, as owner of the resouces, would obviously be seen as the principal. The DWFN's would be seen as the agents. The terms and conditions of access would constitute the incentive scheme.

One attempt to apply principal-agent analysis to coastal state-DWFN relations has recently been published (Clarke and Munro, 1987). The paper is very much a first attempt and, as such, restricts itself to a narrow problem. The problem of surveillance and enforcement, which is in fact a subsidiary principal-agent issue, is pushed into the background. Furthermore, the paper analyzes only "fee" fishing arrangements. (However, one can assert with some assurance that principal-agent analysis will apply to joint-venture arrangements as well.)

The distant-water fleets harvest the resource and in so doing are assumed to produce resource rent. The coastal state, cum principal, is assumed to impose taxes on catch and/or fishing effort. The reward to the DWFN's, cum agents, consists of the resource rent minus the taxes.

Hence, rather than sharing of crops, we have a case of sharing of resource rent. The rent sharing formula—the tax system—constitutes the incentive scheme. While serving to garner a portion of the resource rent for the principal, the taxes serve as well to

influence the DWFN's harvest profile through time. The paper then analyzes the effect of different tax systems in light of the coastal state/principal's goal of maximizing its return from the relevant fishery through time.

It may sound farfetched to place so much emphasis on tax incentives in coastal state-DWFN relations. Yet we have an example of taxes as an incentive scheme from the South Pacific where "fee" fishing arrangements are prevalent. The example appears in a particularly useful recent article on the access arrangements of the largest of the island nations, Papua New Guinea (PNG) (Doulman, 1987).

PNG extracts a return from DWFN fleets by means of access fees. Doulman (1987:19) stated that "By definition access fees are a tax which are essentially designed to extract the resource rent from the fishery; foster operational efficiency in the use of the resource; and provide an instrument for government to regulate, develop, conserve and generally manage the fishery." (See also Clark, 1985:25-26.) The article then goes on to analyze the operation of this tax/incentive scheme in detail.

While it may not in fact be unreasonable to emphasize the use of taxes as an incentive scheme, the paper by Clarke and Munro (1987) is no more than the first step in applying principal agent analysis to terms and conditions of EEZ access. The paper leaves important aspects of "fee" fishing arrangements unexplored. It says nothing about joint venture arrangements and pushes into the background the important surveillance and enforcement problem. What the paper does do, however, is to suggest that principal-agent analysis may be a fruitful approach to studying coastal state-DWFN economic relations.

Conclusions

In this paper I have been concerned with means of analyzing coastal state-DWFN economic relations, as seen from the perspective of coastal states. The fundamental premise has been that, under the rules laid down by the Law of the Sea Convention, the coastal state need establish long-term arrangements with DWFN's only if it is the coastal state's selfish interests to do so. I then argued that the economics of international trade provides analytical tools that are useful in determining whether, in fact, it is in the selfish interest of a coastal state to establish the aforementioned arrangements.

If there is reason to believe that a long-term arrangement with one or more DWFN's could be potentially beneficial for a coastal state, one then requires means of analyzing from an economic perspective the mix of access terms and conditions open to the coastal state. I then argued that a fruitful approach to this question lies in the application of principal-agent analysis.

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Toward a Rational Seafood Trade Policy

DOUGLAS W. LIPTON and ROBERT A. SIEGEL

Introduction

With a record trade deficit of almost $146 billion in 1986, and continued high deficits in 1987, there is growing concern about how continued deficits will affect the U.S. economy. Because fishery products had a record $6.3 billion deficit in 1986, the U.S. National Marine Fisheries Service (NMFS) has made the reduction of the fisheries trade deficit one of its top priorities. A recent NMFS trade objective was to "increase exports and domestic consumption of U.S. fishery products" which would lead to a reduction in the trade deficit. In this paper we explore this policy in terms of practicality and desirability.

Composition of Fishery Trade Deficit

In 1986, over $2.8 billion or 37 percent of U.S. fishery imports were of nonedible products, principally jewelry containing some fish components such as shell. If we examine only edible fishery imports and exports, then the trade deficit is only $3.5 billion. In Figure 1 we see that seafood imports are concentrated in a relatively few products. Shrimp, by far the leading item, makes up 29 percent of edible imports. Groundfish, spiny lobster, tunas, and scallops along with shrimp make up 66 percent of our edible imports.

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Figure 2 demonstrates that edible U.S. seafood exports are even more concentrated than imports. Salmon products, at $726 million, account for 56 percent of edible exports. The next highest products are shrimp ($69 million) and herring ($66 million). The remaining 33 percent of exports are scattered among a variety of products.

When compared with what is occurring in the overall U.S. trade picture, fishery products have actually fared very well. In Figure 3, U.S. exports and imports of fishery products are compared with total merchandise imports and exports. Fishery exports form an increasing percentage of total merchandise exports, and imports a decreasing total.

U.S. Outlook for Seafood Demand

Current data suggest that seafood demand in the U.S. has been rising steadily over the past few years. Figure 4 shows U.S. per capita consumption of seafood and the consumer price index for fish and shellfish. Per capita consumption has gone up steadily since 1982 while real seafood prices have also risen. Rising consumption in the face of higher prices indicates that seafood demand has increased. The most recent increase in demand is partly attributed to an increasing awareness of the healthfulness of seafood, particularly as it relates to heart disease.

A recent study by the Department of Agriculture (Blaylock and Smallwood, 1986) makes projections about the U.S. demand for food to the year 2020, based on the Bureau of Labor Statistics' Continuing Consumer Expenditure Survey. The projections are based on U.S. Census Bureau projections of such factors as the age, racial, and regional distributions of the population, in addition to their own projec-

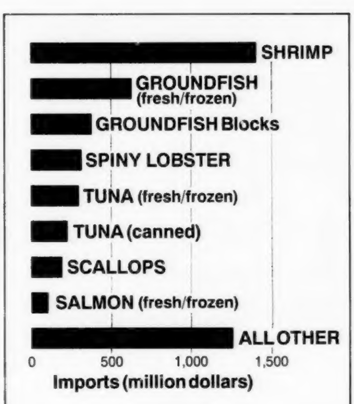

Figure 1.—Edible U.S. seafood imports, 1986.

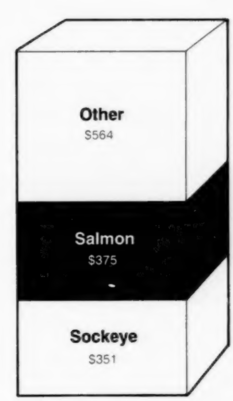

Figure 2.—U.S. edible seafood exports (major products), 1986. Data is in millions of dollars.

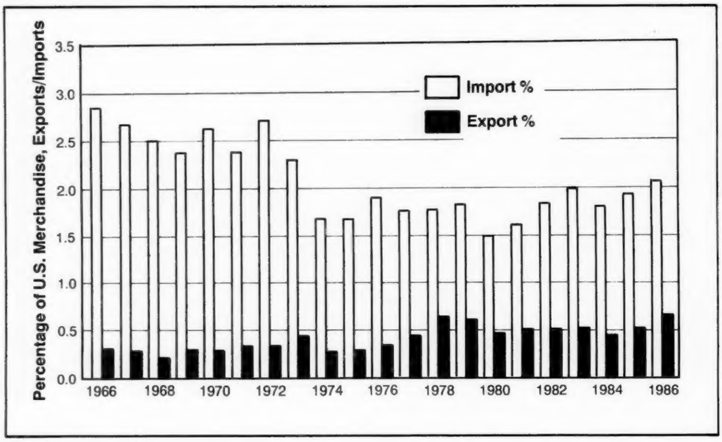

Figure 3.—Fishery exports/imports as a percentage of total U.S. trade.

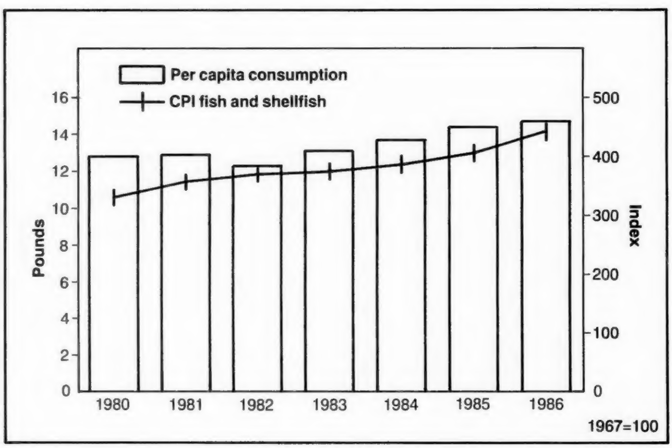

Figure 4.—Per capita seafood consumption and prices (CPI), 1980-86.

tions about consumer income. These projections depend on two key assumptions: 1) Preferences of the demographic groups do not change over time (e.g., as an individual moves into a higher age group he or she adopts the tastes and preferences of that group), and 2) the relative prices of the food groups remain the same. With these caveats in mind, they find that by the year 2000 consumer expenditures on seafood consumed at home will increase by 11.7 percent over 1980 expenditures if consumer incomes increase 1 percent annually; those expenditures will increase by 21.1 percent if incomes increase 2 percent annually. (Census provides a low, middle and high series of projections. All results discussed here are based on the middle series.)

The USDA study estimates what would happen in the seafood market if no other changes occur. In reality, there has been a significant increase in consumer demand for seafood since the expenditure survey was conducted. As a result, we estimate that 1986 at-home seafood expenditures increased by 54 percent over the 1980-81 USDA study. This was due to a 34 percent increase in seafood price and a 15 percent increase in per capita consumption. These estimates far exceed the USDA projections. However, we assume that the demographic changes leading to changes in seafood demand occur on top of the recent increase in demand, and that percentage increases in expenditures predicted by the USDA model are still valid. Projections, however, will be more meaningful if they are made from the higher base of 1986 consumption and expenditures.

According to the BLS 1980-81 consumer expenditure survey, weekly per capita food expenditures were $19.49, with $13.18 at home and $6.31 away from home. Expenditures on seafood during this period were 3.1 percent of the at-home food expenditures or $0.41 per person per week. This was equivalent to total annual expenditures for seafood at home of $4.82 billion. NMFS estimates of total seafood expenditure during this period was $12.84 billion. Thus, it was estimated that $8.02 billion was spent on seafood away from home. This is approximately 11 percent of the total away-from-home food expenditures estimated in the BLS survey. Since seafood consumed during the 1980-81 period averaged 2.92 billion pounds edible weight, the average retail price for seafood was calculated as $4.40 per pound.

Updating the above calculations to 1986, we find that at-home seafood expenditures were $7.67 billion, or $0.62 per person per week. Away-from-home expenditures were $12.56 billion, or $1.01 per person per week. The total of $20.2 billion represents a nominal increase in seafood expenditures of 58 percent over 1980 expenditures.

Using the USDA projections, in the year 2000, at-home seafood per capita expenditures will increase from 9.3

percent to 17.1 percent over 1985 expenditures. Using 1986 expenditures data as a base, this translates to an at-home per capita seafood expenditure of $0.67-$0.73 per week. Away-from-home seafood expenditures will increase to $1.09-$1.22 per week. Total annual seafood expenditures in the year 2000 are thus estimated to be $24.52-$27.17 billion. Using the assumption that real seafood prices do not increase after 1986, the quantity of seafood consumed will increase to 4.16-4.61 billion pounds edible weight. This means that per capita consumption will increase another 5-17 percent (15.5-17.2 pounds per person). Thus, for there to be no real increase in seafood prices, supplies of edible seafood will have to rise 18-31 percent over 1986 levels. These projections are summarized in Table 1.

Table 1.—Seafood expenditure and consumption.

Item	Expenditures (× 1,000) and consumption		
	1980-1981[1]	1986[2]	2000[3,4]
At-home	$4,820	$ 7,670	$ 9,34-$10,170
Away-from-home	$8,020	$12,560	$15,190-$17,000
Per-capita consumption	12.9 lb.	14.7 lb.	15.5-17.2 lb.

[1]Sources: Blaylock and Smallwood, 1986; Fisheries of the United States, various years.
[2]Estimate.
[3]Projection, low figure based on 1 percent annual rise in consumer income, high figure on 2% rise.
[4]Assumes no real price change for seafood.

Table 2.—Alternative seafood supply scenarios in the year 2000.

Scenario	Domestic landings (million lb.)	Imports (million lb.)	Price change (%)	Per capita consumption lb.)
Base	3,393	7,360-8,157	0	15.5-17.2
1986 Supplies	3,393	6,227	14-21	13.1
U.S. landings grow	4,526-5,323	6,227	0	15.5-17.2

Outlook for U.S. Seafood Supply

The real price of seafood has risen considerably since the time that the BLS survey was conducted. Yet, the projections from the USDA study relied strongly on the assumption that seafood prices would remain steady. This assumption would be valid if supply were able to expand at the same rate as demand. However, with fishery resouces this is not likely to be the case. Domestic commercial landings have actually declined from 1980 to 1986 by 7 percent. To keep up with increasing demand, imports increased by 20 percent over the same period. The increase in imports was partially fueled by a strong U.S. dollar making imports relatively cheap, but this was still not enough to offset the increase in demand, and prices rose 34 percent.

To account for different supply conditions and the result it will have on seafood prices, expenditures and quantity consumed, we took an ad hoc approach by incorporating a price elasticity from another study in the USDA model. Price elasticity measures the percentage change in quantity consumed of a commodity due to a 1 percent change in its price. A recent study by Cheng and Capps (1986) calculated an elasticity of -0.89 for shellfish and -0.67 for finfish. These values are considered inelastic in that the percentage change in quantity is smaller than the percentage change in price. For total seafood elasticity, we used the midpoint of the elasticity estimates, -0.78.

Although it is not a statistically valid procedure to append the elasticities to the USDA model, doing so provides a rough idea of seafood consumption under various scenarios, without having to incur the costs of estimating a new model. The scenarios are based on different assumptions about price changes, U.S. landings, and import levels. The results of the scenarios are summarized in Table 2. The first scenario or base case is the one discussed above where it is assumed there are no price changes and U.S. landings are at their 1986 levels. In scenario two, U.S. landings and imports are set at their 1986 levels, resulting in a 14-21 percent rise in real price and a decline in per capita consumption to 13.1 pounds per person. The third scenario keeps imports at their 1986 levels and shows the increase in U.S. supplies necessary to keep prices at their 1986 levels. These scenarios represent extremes. It can be expected that some supplies will be due to increased U.S. landings, some from imports, and that some demand will not be met by increased supplies leading to a real price rise.

Potential Supply

The techniques employed here are not suited to breaking out how the increase in demand will affect individual seafood products. In fact, by aggregating all edible seafood into a single category, the approach assumes that the relative quantities consumed of each product do not change. Thus, an increase in seafood consumed of 18-31 percent, as predicted in the base scenario, translates into an increase of 18-31 percent for shrimp, salmon, groundfish, etc., over the 1986 levels.

We realize that the supply situation in fisheries can vary greatly from year to year for individual products. It is unlikely that the supply will expand such that all species are produced in the same proportions. It is more likely that supplies of some species will be higher and some lower. Consumers will substitute accordingly, and prices will adjust. For example, increases in domestic processing of Alaskan pollock are likely to exceed the 31 percent limit in the base scenario. This, however, may make up for shortages in other groundfish species. The lowering in price due to large pollock supplies will depend on how closely consumers' perceive pollock as a substitute for groundfish and other products. The closer the substitute, the less the price decrease. Much of the pollock will be transformed into surimi and eventually analog seafood products. It is unknown where these analog products fit in seafood consumption patterns. Are they substitutes for other seafood, or expanding seafoods substitutability for other protein such as chicken or soy?

The potential for the expansion in supplies of major seafood products varies by product. The most important product, shrimp, has the greatest potential for expansion of supply. This is

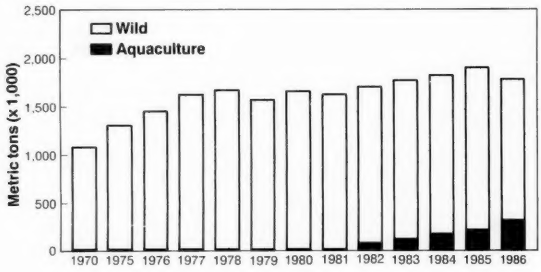

Figure 5.—World shrimp catch.

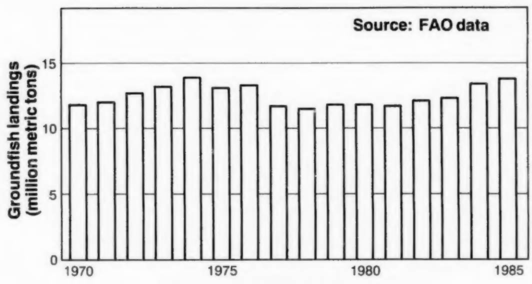

Figure 6.—World groundfish landings, 1970-85.

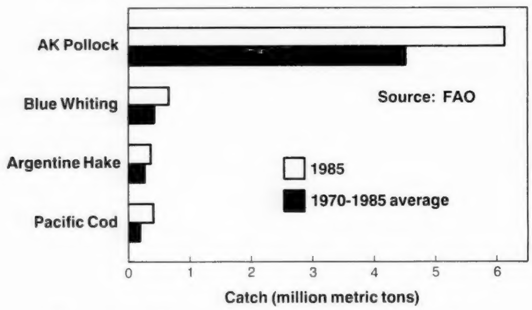

Figure 7.—Major groundfish species with increasing catches.

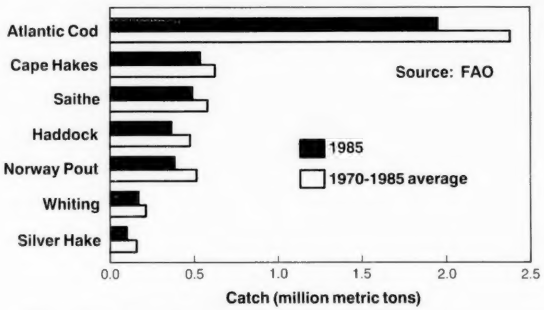

Figure 8.—Major groundfish species with decreasing catches.

due to the rapidly increasing production of farmed shrimp. Although world production of wild shrimp has been fairly constant, aquaculture production has begun to rise tremendously (Fig. 5). In contrast, the potential for increases in world groundfish supplies is limited. Without aquaculture, production of these products has not increased over time (Fig. 6). Although certain products such as Alaska pollock and blue whiting have increased, these have replaced major species that have decreased such as Atlantic cod and haddock (Fig. 7, 8). This shift in species distribution of the groundfish catch has been favorable to the United States because of the large Alaska pollock resource in the U.S. exclusive economic zone.

Summary and Conclusions

The record seafood trade deficit is not a problem, but a sign of growing demand for seafood products. The United States cannot supply this growing market with domestic resources; it must continue to import more seafood products. Any policies that promote domestic consumption and exports lead to upward pressure on seafood prices and greater demand for imports. There are ways, however, that the growth in imports can be tempered. Some U.S. fish stocks (e.g., Atlantic groundfish) are depleted to a level where the sustainable yield is well below the stocks' potential if allowed to rebuild. Reducing fishing pressure on these stocks can result in higher landings in the long run, reducing the dependence on imports.

Another area where the U.S. can displace imports with domestic landings is through developing substitutes for traditional fishery products. The best example of this approach is the use of surimi-based products to simulate items such as crab legs or shrimp. Still another approach is to get consumers to accept species available in the U.S. exclusive economic zone as substitutes for products that are imported.

Last, we propose that demand for imports can be tempered by removing the natural obstacle presented by the environment to increased U.S. production. In other words, the development of an aquaculture industry would allow seafood producers to expand production in response to real price increases for their product. The major aquaculture successes in the United States are currently catfish, trout, and crayfish. There is tremendous potential for salmon aquaculture and perhaps many other species demanded by U.S. consumers.

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A U.S. Perspective on Access to Fisheries Resources

LARRY L. SNEAD

The passage of the Magnuson Fishery Conservation and Management Act of 1976 (MFCMA) and the establishment of a 200-mile exclusive economic zone (EEZ) in 1983 have resulted in a radical change in the pattern of foreign fishing operations off the U.S. coasts. Likewise, the extensions of 200-mile EEZ's by other nations have impacted U.S. distant-water fisheries. The result has been that a new international framework for fisheries is emerging and is continuing to evolve.

U.S. international fisheries policies have paralleled this change in the pattern of access to fisheries resources. In the 10 years following the passage of the MFCMA, emphasis was placed on policies designed to promote the rapid development of the U.S. fishing industry within the U.S. EEZ. In this process, the allocation to foreign countries of surplus fish stocks in the U.S. EEZ was the primary tool by which those countries were encouraged to assist in the U.S. industry's development.

In recent years, however, the U.S. harvesting and processing sectors have displaced most foreign fisheries in U.S. waters. Allocations to foreign countries have declined from more than 2 million metric tons (t) in 1977 to less than 200,000 t in 1987. Consequently, foreign fishermen are rapidly being replaced by U.S. fishermen and increased domestic emphasis is now being placed on issues relating to fisheries activities beyond the EEZ. These issues include access to resources in other countries' waters, the problems surrounding straddling and transboundary stocks, and issues related to fisheries trade.

I would first like to review the progress we have made in the evolution of U.S. fisheries policy in the decade following the introduction of the MFCMA in 1976, and some of the key responsibilities of the Department of State. Upon the MFCMA's entry into force on 1 March 1977, the United States suddenly had under its jurisdiction an enormous fisheries resource, much of which had previously been targeted only by foreign countries. In the waters off Alaska, for example, the United States now controlled a groundfish fishery in which U.S. fishermen had almost no previous participation. The MFCMA's objective to promote the complete domestic utilization of the fish stocks in the U.S. EEZ and to phase out foreign fishing has proven to be a monumental, but achievable task.

Following MFCMA passage, one of the first challenges we faced at the Department of State was the negotiation of bilateral framework agreements with foreign countries which desired to fish in the U.S. 200-mile zone. These agreements, called "GIFA's" simply spelled out the principals and procedures under which countries could apply to fish; they did not guarantee fisheries access, nor did they guarantee fishery economic benefits to the United States. Currently, ten such agreements are in force.

The MFCMA also gives the Department of State responsibility over the allocation of fish to foreign countries which have concluded GIFA's and which apply to fish in the U.S. zone. The allocation of surplus fish stocks to foreign countries since the late 1970's has reflected our concern for conservation as well as development. The MFCMA originally mandated that allocations be made to foreign countries on the basis of four factors: 1) Traditional fishing patterns, 2) contributions to research on U.S. stocks, 3) adherence to U.S. fisheries regulations, and 4) other appropriate factors (the so-called basket clause). Under these guidelines, foreign fishing effort was substantially reduced on major traditional fisheries such as herring (Clupeidae), mackerel, *Scomberomorus* sp.; butterfish (Stromateidae), yellowfin sole, *Limanda aspera*; and Pacific ocean perch, *Sebastes alutus*, in the late 1970's to provide for the recovery of U.S. fisheries.

However, in addition to curbing overfishing, the rapid development of the U.S. fishing industry required domestic expansion into the nontraditional groundfish fisheries that had not previously been exploited by the U.S. industry. It became clear early on that allocations represented strong leverage by which foreign countries could be encouraged to assist in the U.S. industry's development and expansion.

In 1980, the MFCMA was amended to add four new criteria to the list of those which must be considered when making allocations. These were: 1) Barriers to the import of U.S. fisheries products, 2) purchases of U.S. fisheries products, 3) participation in the development of the U.S. fishing industry, and 4) domestic consumption considerations. This amendment ushered

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in the so-called "fish and chips" policy under which foreign country performance in such matters as the purchase of fish from the U.S. industry and the elimination of trade barriers were specifically added as factors to be taken into account in the allocation process.

Although directed foreign fishing in the U.S. EEZ was increasingly being curtailed in the early to mid-1980's, allocation policy continued to provide important leverage in promoting the utilization of U.S. fisheries resources by the U.S. industry. Particularly important was the use of allocations to encourage the rapid expansion of "over-the-side" joint ventures, in which fish harvested by U.S. vessels is sold at sea to foreign processors. This type of joint venture (J/V) was extremely successful in providing alternative offshore markets for U.S. fishermen.

Joint ventures increased dramatically in size from a mere 33,000 t in 1980, to 350,000 t in 1984, and to an estimated 1.5 million t in 1987. The growth of the J/V fisheries was responsible for the nearly complete displacement of directed foreign fishing by U.S. fishermen in less than a decade. Because of the limited overall availability of fish in the U.S. zone, we are rapidly reaching the point where J/V fishing will necessarily peak out. We expect J/V's to be gradually phased out also as development continues in the domestic shorebased processing industry.

Our objective to promote the development of the processing sector of the U.S. industry has been less dramatic than in the "over-the-side" joint venture area, but some positive movement has been made relatively recently in this area. For example, through the industry to industry forum, Japan agreed in 1985 to assist the U.S. industry through investment in surimi plants in Alaska and through a liberalization of its import quota system. The Department and other U.S. interests are continuing their efforts to encourage additional benefits for the U.S. processing industry through the establishment of equity joint ventures, further trade liberalization, etc.

In addition to the goal of full domestic utilization of the EEZ for the benefit of U.S. harvesters and processors and for the phaseout of foreign activities in the U.S. zone, the focus of U.S. international fisheries policy and the responsibilities of the Department of State under the MFCMA also concern fisheries issues beyond the U.S. EEZ. Together with opportunities for domestic expansion within the U.S. 200-mile zone, some important sectors of the U.S. industry are looking toward maintaining and possibly increasing their access to stocks in the EEZ's of other countries. The negotiation of favorable access agreements for the benefit of U.S. distant-water fisheries is thus important in our overall fisheries policy and is an important mandate of the Department of State under the MFCMA.

Earlier in 1987, for example, following years of intensive negotiations, a South Pacific Regional Fisheries Treaty was signed with 16 island nations which will permit access for the U.S. tuna industry to some 10 million square miles of rich fishing waters in the South Pacific Ocean. Access to these resources will be on the basis of annual regional licenses issued by the South Pacific Forum Fisheries Agency (FFA). Associated with the treaty is an agreement between the U.S. government and the FFA which provides an annual assistance package of $10 million to the Pacific Island States. The agreement, which will run for 5 years, will help ensure a viable future for U.S. tunaboat operators and processors in the South Pacific Ocean. In addition, the treaty will resolve a serious foreign policy problem for the U.S. government generated by U.S. fishing activities in the region.

The Department has also initiated negotiations with the Soviet Union regarding possible access by U.S. fishermen to resources in the Soviet EEZ. This effort is in response to requests by some sectors of the U.S. industry, in particular the crab harvesting sector, to explore potential opportunities with the Soviet Union. Following two rounds of talks, we are cautiously optimistic that some type of agreement can be reached. At the same time, however, the Soviet Union has been certified by the Department of Commerce under the Packwood Amendment for whaling policies that are deemed to undermine the objectives of the International Whaling Commission and cannot presently receive any allocations in the U.S. EEZ. This remains a complicating factor in these talks.

Aside from, but related to, the issue of fisheries access, the Department has placed increased emphasis on conservation issues beyond the EEZ which may affect fisheries within the EEZ. For example, as foreign countries have been phased out of the groundfish fisheries in both the U.S. and Soviet EEZ's, fishing effort in the international waters of the Bering Sea (the so-called donut hole) has grown dramatically. This effort, which some observers believe may exceed some 700,000 to 1,000,000 t in 1987, threatens to undo the conservation gains which have been made in the EEZ. We are at present [1987] attempting to obtain timely information from all countries fishing in this area so that the domestic fisheries management bodies can begin to analyze what effects this fishery may have on Walleye pollock, *Theragra chalcogramma*, stocks in U.S. waters. The longer term resolution of this issue is a matter which will require extensive consideration. As noted earlier, significant progress has been made in using allocations as leverage in promoting the full development of the zone by U.S. harvesters and processors. However, allocations have been phased out almost entirely and our leverage in dealing with problems such as the donut area and similar issues has also been reduced.

The Department is also involved in addressing complex transboundary stock issues with our neighbors, Mexico and Canada. One such issue concerns the anchovy (Engraulidae) and king mackerel, *Scomberomorus cavalla*, stocks shared between the United States and Mexico. In the case of anchovy, although we have long been interested in improving coordina-

tion of bilateral management measures for these stocks, Mexico has not shared our perception of the urgency for coordination. In the case of king mackerel, it is generally believed that there is a relationship between stocks harvested off Mexico and those harvested in the U.S. EEZ in the Gulf of Mexico. While we have undertaken some preliminary research with Mexico and have discussed the issue in the context of MEXUS Gulf, much remains to be done.

A similar situation exists regarding transboundary stocks on Georges Bank. For example, Canada has requested on several occasions that we seek ways to expand bilateral coordination of haddock management in this area. While we are willing to do so, it is difficult at present to give detailed consideration to bilateral coordination of management measures. The two countries presently take different approaches in their respective policies on groundfish management. As with the other problems on complex and politically sensitive transboundary and straddling stock issues, a resolution is likely to require extensive discussions over a period of time between the parties involved.

A related area of concern has been access to fisheries stocks outside Canada's 200-mile zone on the east coast. Since October 1984, when U.S. fishermen lost a significant portion of Georges Bank as the result of the Gulf of Maine maritime boundary adjudication by the World Court, a number of U.S. vessels returned to their former traditional fisheries in the Northwest Atlantic Fisheries Organization (NAFO) regulatory area. This has created a difficult situation because the United States is not a member of NAFO, nor has the organization come to grips with the issue of nonmember fishing, other than to urge that such fishing cease. The current NAFO members, of course, do not wish to see their quotas impacted as a result of fishing by additional nonmember countries. It has been suggested that nonmembers, such as the United States, join NAFO, but, realistically, membership holds few attractions without an assurance that adequate shares in NAFO quotas would be available to new members.

Under the MFCMA, the Department also has the lead on negotiations regarding the protection of U.S.-origin salmonids and this has long been a major area of concern in U.S. international fisheries policies. In recent years, we have concluded a number of successful agreements regarding anadromous species on both coasts. In 1983, the North Atlantic Salmon Conservation Organization Protocol was signed to provide for the protection of North Atlantic salmon from high seas harvests. Two years later, an agreement was reached with Canada, after some 14 years of talks, on the complex issue of regulating fisheries within the 200-mile zone of each country which harvests salmon originating in the other country's rivers. Finally, in 1986, the International North Pacific Fisheries Commission Protocol was amended to provide additional restriction on Japan's high seas harvest of salmon of North American origin.

As mentioned, fisheries trade issues became much more focused as a U.S. objective and were specifically included among the criteria we review prior to making decisions on the allocation of surplus fisheries resouces in the U.S. EEZ under a 1980 amendment to the MFCMA. However, the main focus of activity on fisheries trade issues has centered on mechanisms unrelated to the allocation process.

An excellent example of this emphasis is the trade agreement with Japan on pollock and herring quotas reached in March 1987. Following six rounds of talks from September 1986 to March 1987, chaired by the U.S. Trade Representative's office in cooperation with the Departments of State and Commerce, an agreement was reached by which Japan agreed to remove important nontariff barriers to imports of U.S. produced pollock and herring products. It established for the first time a system by which any willing buyer will have easy access to Japanese fish import quotas on these items. The agreement is of great significance to the developing U.S. surimi industry and the Department of Commerce estimates that it will facilitate a vast increase in U.S. surimi exports to Japan. As we continue to develop the domestic capacity to fully utilize the fish resources in the U.S. zone, efforts to open and stabilize access for U.S. produced fish through international channels will become increasingly important.

In summary, the dramatic changes which have taken place in U.S. fisheries have resulted in a fundamental shift in the emphasis of U.S. international fisheries policies. In the first decade following the MFCMA's implementation, the main goal was the development of fisheries within the U.S. 200-mile zone through the control of large surplus fisheries resources. Now that this goal is clearly in sight, major new emphasis is being placed on international problems we face regarding fishery issues beyond the EEZ. These have taken the form of either a desire for access to fish stocks outside the U.S. EEZ, an interest in ensuring that fisheries beyond U.S. waters do not adversely affect the conservation of stocks within the zone, or efforts to expand foreign markets for U.S. produced fishery products. Based on recent trends, it is likely that this process will continue and that U.S. policies will increasingly be directed toward working out solutions to such difficult issues through international negotiations and cooperation with other countries.

Canadian, Mexican, and U. S. Fisheries: Recent Developments

GIULIO PONTECORVO

Introduction

The creation of extended zones (EEZ's) has shifted some aspects of fisheries management and policy from the arena of international negotiations to the economic and political decision making process within the coastal state. The transition from a world of international commons to one of coastal state jurisdiction raises a variety of issues. The one of concern here is a broad welfare question: Given the transfer of assets from the international commons to the coastal state, how well (efficiently) has the state used these new assets to increase the flow of income and Gross National Product (GNP)?

Under the usual assumptions, any increase in GNP with a given distribution of income suggests a welfare improvement. However, in the case of fisheries, the usual assumptions must be augmented by recognition of the central role of the common property problem in the analysis. While the GNP welfare framework provides theoretical guidelines for future macroeconomic evaluation of fisheries, here, perforce, we are limited to a statistical description of what has been recent history and some preliminary remarks suggestive of a research agenda.

Linking the national interest to the creation of EEZ's (i.e., to the acquisition of assets and the associated flow of income represented by fish stocks in the EEZ's) allows analysis of the economics of fisheries to include macroeconomic questions as well as the analysis of firm and industry problems. This paper emphasizes the national interest and in so doing it distinguishes itself from the current focus on local and regional interests which is embedded in the regional fisheries councils created by the 1976 Act. As with any macroeconomic approach, the underlying changes (the determination of economic and biological optima, etc.) in micro conditions are subsumed in the aggregation process. This neither asserts nor denies the validity of either body of analysis; it merely suggests a complementary approach (Pontecorvo et. al., 1980; Pontecorvo[1]).

In any empirical economic analysis of fisheries, it is banal to point out the importance of data problems, yet here it is useful to note that worldwide we have only the Food and Agriculture Organization's (FAO) data on catch. There are national statistics for a few countries on capital and labor. Further, data on costs of production, prices, etc., are available only in limited circumstances. Here we will use FAO catch data and statistics on capital and labor found in the U.S. annual publications "Fisheries of the United States."

The first section of this paper will review briefly the catch statistics for three countries of North America—Canada, Mexico, and the United States—from 1970 to date. In addition to changes in gross catch, changes by fishing area (as designated by FAO) will be noted as well as changes in the species caught. Three-year averages (e.g., 1970-72, etc.) are employed to reduce the impact of population variation and random events which influence landings.

The next section provides estimates of the gross value of the catch and a crude index of the value of the stocks. A final section will comment briefly on the relationship between long-run equilibrium in fisheries and short-run changes including the interaction between fisheries and the business cycle. It will also note problems in the measurement of technological change and productivity in fisheries.

Landings

Figure 1 shows the important geographic areas fished by the three countries. Table 1 notes the change in aggregate catch from 1970 to 1985.

[1]Pontecorvo, G. 1988. The enclosure of the marine commons: Adjustment and redistribution in world fisheries. Mar. Pol. 12(4).

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Table 1.—Catch by country (source, FAO data).

Nation	Average of 1970-72 (1,000 t)	Percent of world total	Average of 1976-78 (1,000 t)	Percent of world total	Average of 1983-85 (1,000 t)	Percent of world total	Gain/loss: Avg. (1983-85) less avg. (1970-72)	Gain/loss: Avg. (1983-85) less avg. (1976-78)
Canada	1,200.7	2.1	1,190.3	1.9	1,307.1	1.8	106.4	116.8
Mexico	382.5	0.7	588.6	1.0	1,021.2	1.4	638.7	432.6
United States	2,737.8	4.7	3,073.8	5.0	4,538.3	6.3	1,800.5	1,464.5
Total	3,120.30	5.4	3,662.4	6.0	5,559.5	7.7	2,439.2	1,897.1

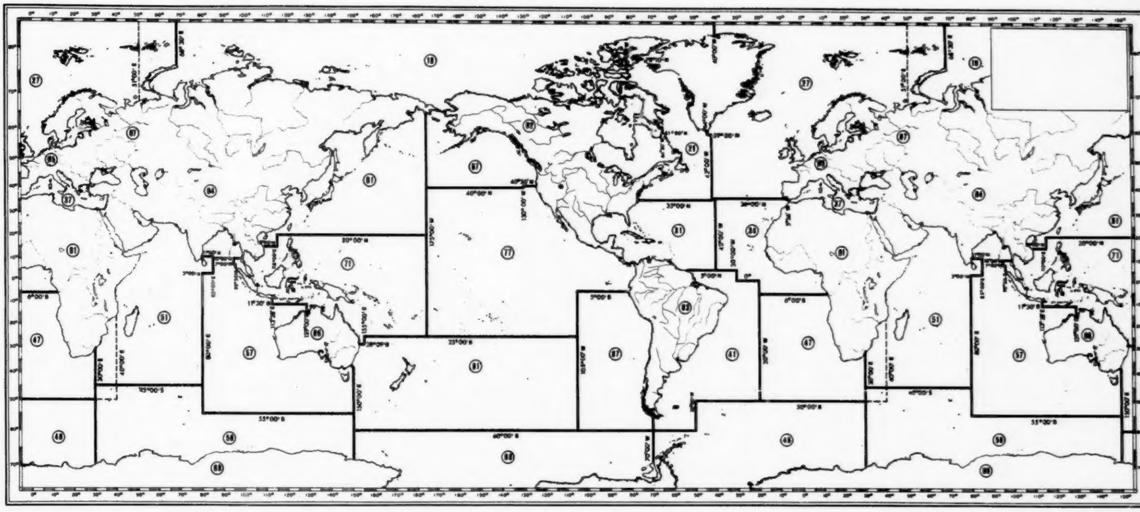

Figure 1.—Major fishing areas of the world for statistical purposes (source: FAO). Numbered major fishing areas of interest: 18, Arctic Sea; 21, Northwest Atlantic; 27, Northeast Atlantic; 31, Western Central Atlantic; 34, Eastern Central Atlantic; 37, Mediterranean and Black Seas; 41, Southwest Atlantic; 47, Southeast Atlantic; 48, Antarctic Atlantic; 51, Western Indian Ocean; 57, Eastern Indian Ocean; 58, Antarctic Indian Ocean; 61, Northwest Pacific; 67, Northeast Pacific; 71, Western Central Pacific; 77, Eastern Central Pacific; 81, Southwest Pacific; 87, Southeast Pacific; and 88, Antarctic Pacific.

Collectively the three countries both increased their catch by 2,500,000 metric tons (t) and also their share of world catch by more than two percent. The observed increase in landings involved enforced reduction of foreign fishing effort in the three EEZ's, the acquisition of a share of that catch by the fishermen of the coastal state, and recovery of certain stocks from reduced levels in the 1960's. The United States accounted for the bulk of the gains while Mexico had the largest percentage increase. By 1983-85, Mexican landings were more than 1,000,000 t, which placed Mexico among the first 18 countries in worldwide landings.

Table 2.—Canadian, Mexican and U.S. catch in selected fishing areas (sources: FAO data).

Nation/area	Ave. of 1970-72 (1,000 t)	% of total catch	Ave. of 1976-78 (1,000 t)	% of total catch	Ave. of 1983-85 (1,000 t)	% of total catch	Gain/loss: Avg. (1983-85) less avg. (1970-72)	Gain/loss: Avg. (1983-85) less avg. (1976-78)
Canada								
Northwest Atlantic	1,066.2	88.8	990.2	83.2	1,116.0	85.4	49.8	125.8
Northeast Pacific	130.4	10.9	195.3	16.4	191.2	14.6	60.8	(4.1)
East Central Pacific	3.3	0.3	4.8	0.4	0.0	0.0	(3.3)	(4.8)
East Central Atlantic	0.7	0.1	0.0	0.0	0.0	0.0	(0.7)	0.0
Total (4 areas)	1,200.6	100.1	1,190.3	100.0	1,307.2	100.0	106.6	116.9
Mexico								
East Central Pacific	261.4	68.4	453.9	77.1	728.9	71.4	467.5	275.0
East Central Atlantic	121.1	31.7	133.4	22.7	282.9	27.7	161.8	149.5
Northwest Pacific	0.0	0.0	1.3	0.2	9.5	0.9	9.5	8.2
Total (3 areas)	382.5	100.1	588.6	100.0	1,021.3	100.0	638.8	432.7
United States								
West Central Atlantic	1,051.6	38.4	1,118.6	36.4	1,641.5	36.2	589.9	522.9
Northeast Pacific	368.4	13.5	478.9	15.6	1,300.8	28.7	932.4	821.9
Northwest Atlantic	979.4	35.8	1,057.7	34.4	1,234.7	27.2	255.3	177.0
East Central Pacific	319.1	11.7	407.1	13.3	217.4	4.8	(101.7)	(189.7)
West Central Pacific	0.0	0.0	0.0	0.0	140.9	3.1	140.9	140.9
Total (5 areas)	2,718.5	99.4	3,062.3	99.7	4,535.3	100.0	1,816.8	1,473.0

In recent years the Canadian fishing effort has been limited to two geographic areas—the Northwest Atlantic and the Northeast Pacific (Table 2). More than 85 percent of Canadian landings by physical volume are from the Atlantic. The growth of the Canadian catch since 1970-72 has been modest; more recently, however, Canada's east coast fisheries have recovered substantially from the depressed period of the mid 1970's.

Table 3.—Catch by species for Canada, Mexico, and the United States (source: FAO data).

Species	Canadian catch					Mexican catch					U.S. catch				
	Avg. of 1970-72 (1,000 t)	% of total catch	Avg. of 1983-85 (1,000 t)	% of total catch	Gain or loss[1]	Avg. of 1970-72 (1,000 t)	% of total catch	Avg. of 1983-85 (1,000 t)	% of total catch	Gain or loss[1]	Avg. of 1970-72 (1,000 t)	% of total catch	Avg. of 1983-85 (1,000 t)	% of total catch	Gain or loss[1]
Salmons, trouts	74.5	6.2	79.7	6.1	5.2	0.0	0.0	0.0	0.0	0.0	148.5	5.4	312.0	6.9	163.5
Flounders, halibuts	160.5	13.4	113.7	8.7	(46.8)	0.3	0.1	0.8	0.1	0.5	88..6	3.2	214.9	4.7	126.3
Cods, hakes	304.6	25.4	583.7	44.7	279.1	0.0	0.0	0.0	0.0	0.0	64.1	2.3	719.0	15.8	654.9
Redfishes, basses	118.5	9.9	94.9	7.3	(23.6)	33.9	8.9	52.4	5.1	18.5	96.5	3.5	157.3	3.5	60.8
Jacks, mullets	3.5	0.3	37.2	2.8	33.7	10.0	2.6	18.4	1.8	8.4	46.1	1.7	38.3	0.9	(7.8)
Herrings, sardines	417.6	34.8	187.6	14.4	(230.0)	52.1	13.6	472.1	46.2	420.0	1,018.8	37.2	1,393.1	30.7	374.3
Tunas, bonitos	9.3	0.8	1.0	0.1	(8.3)	22.6	5.9	83.8	8.2	61.2	238.9	8.7	268.8	5.9	29.9
Mackerels, snoeks	15.7	1.3	20.8	1.6	5.1	0.4	0.1	5.2	0.5	4.8	3.2	0.1	41.6	0.9	38.4
Sharks, rays	0.7	0.1	3.2	0.2	2.5	8.8	2.3	33.0	3.2	24.2	1.4	0.1	11.2	0.3	9.8
Misc. marine fishes	4.5	0.4	29.3	2.2	24.8	121.1	31.7	199.6	19.5	78.5	67.0	2.5	48.1	1.1	(18.9)
Sea-spiders, crabs	7.8	0.7	44.8	3.4	37.0	1.0	0.3	7.4	0.7	6.4	133.1	4.9	146.3	3.2	13.2
Lobsters	16.7	1.4	29.6	2.3	12.9	1.9	0.5	2.1	0.2	0.2	19.9	0.7	22.9	0.5	3.0
Shrimps, prawns	2.2	0.2	14.0	1.1	11.8	71.8	18.8	75.9	7.4	4.1	173.2	6.3	139.2	3.1	(34.0)
Oysters	4.2	0.4	4.6	0.4	0.4	34.5	9.0	40.7	4.0	6.2	338.3	12.4	283.9	6.3	(54.4)
Scallops, pectins	45.3	3.8	44.7	3.4	(0.6)	0.0	0.0	0.0	0.0	0.0	42.1	1.5	283.9	6.3	241.8
Clams, cockles	5.8	0.5	11.8	0.9	6.0	6.5	1.7	8.4	0.8	1.9	223.0	8.1	394.0	8.7	171.0
Squids, octopuses	0.6	0.1	0.3	0.0	(0.3)	2.7	0.7	7.6	0.7	4.9	12.7	0.5	25.2	0.6	12.5
Total	1,192.0	99.7	1,300.9	99.6	108.9	367.6	96.2	1,007.4	98.4	639.8	2,715.4	99.1	4,499.7	99.4	1,784.3

[1]Average (1983-85) minus average (1970-72).

Table 4.—Catch by country by area and species in thousands of metric tons (source: FAO data).

Species	Northwest Atlantic						West Central Atlantic			
	Canada		U.S.		Mexico		U.S.		Mexico	
	M3[1]	M3-M1[2]	M3	M3-M1	M3	M3-M1	M3	M3-M1	M3	M3-M1
Salmons, trouts	2.1	(1.5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Flounders, halibuts	105.5	(34.6)	67.0	15.7	0.0	0.0	4.0	1.6	0.0	0.0
Cods, hakes	579.1	279.8	102.7	45.3	0.0	0.0	0.0	0.0	0.0	0.0
Redfishes, basses	71.5	(41.2)	31.3	(11.2)	0.0	0.0	20.5	(7.7)	35.1	10.2
Herrings, sardines	154.6	(245.4)	351.9	58.1	0.0	0.0	978.0	327.0	4.0	3.4
Tunas, bonitos	0.9	(1.8)	4.3	1.6	9.4	9.4	10.0	2.3	9.3	3.3
Misc. marine fishes	0.9	(2.1)	8.0	(12.1)	0.0	0.0	36.9	(8.7)	118.2	103.6
Sea-spiders, crabs	43.7	36.9	56.1	16.4	0.0	0.0	38.4	8.7	6.9	6.0
Scallops, pectins	44.7	(0.5)	72.1	45.2	0.0	0.0	207.5	196.5	0.0	0.0
Total	1,003.0	(10.4)	693.4	159.0	9.4	9.4	1,295.3	519.7	173.5	126.5

Species	West Central Atlantic		East Central Pacific				Northeast Pacific			
	U.S.		U.S.		Mexico		Canada		U.S.	
	M3	M3-M1	M3	M3-M1	M3	M3-M1	M3	M3-M1	M3	M3-M1
Salmons, trouts	0.0	0.0	1.2	(1.0)	0.0	0.0	77.6	6.7	310.8	164.
Flounders, halibuts	0.0	0.0	6.8	1.6	0.8	0.4	8.1	(12.3)	137.0	107.
Cods, hakes	0.0	0.0	0.0	0.0	0.0	0.0	4.6	(0.7)	616.2	609.
Redfishes, basses	0.0	0.0	14.4	11.4	17.2	8.3	23.5	17.6	25.4	68.
Herrings, sardines	0.0	0.0	83.7	(52.7)	468.1	416.6	33.0	15.4	16.4	42.
Tunas, bonitos	0.0	(19.3)	108.5	(84.9)	65.1	48.4	104.7	(2.4)	2.0	(13.)
Misc. marine fishes	0.0	0.0	2.2	0.9	81.4	(25.2)	28.4	26.9	1.0	0.
Sea-spiders, crabs	0.0	0.0	1.1	((1.2)	0.5	0.3	1.1	0.1	117.2	(10.)
Scallops, pectins	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.
Total	0.0	(19.3)	217.9	(125.9)	633.1	448.8	281.0	51.3	1,230.3	968.

[1]M3: Average 1983-85
[2]M1: Average 1970-72

Mexican landings have also come primarily from two areas, the Eastern Central Pacific and the Western Central Atlantic, with more than 70 percent of Mexican production from the Eastern Central Pacific.

The United States fishes in five areas with more than one-third of the catch coming from the Eastern Central Atlantic and slightly less than 30 percent coming from the Northeast Pacific and the Northwest Atlantic. The most rapid growth in U.S. landings has been in the Northwest Pacific.

If we look at the species of fish caught, as classified by the FAO, (Table 3) 9 percent of Canada's landings in 1983-85 were flounders, halibuts, etc.; 45 percent cods, hakes, haddocks, etc; and 14 percent are herrings, sardines, anchovies, etc., so that more than two-thirds by volume of the Canadian catch is in these three categories. Similarly, the Mexican catch is heavily concentrated in two categories, as 46 percent of the Mexican catch consists of herrings, sardines and anchovies, etc., and another 20 percent by volume comes from miscellaneous marine fishes. The U.S. catch is somewhat more varied, with 31 percent in herrings, sardines, anchovies, etc., and another 16 percent classified as cods, hakes and haddocks, etc.

The breakdown by country, area and species can be combined to indicate the catch by country, by area and by species caught in each area (Table 4). More than 40 percent of the Canadian catch consists of cods, etc., caught in the maritimes. It is the recovery in these fisheries since the early 1970's that accounts for much of the overall increase in the volume of Canadian landings.

In Mexico, the increase in landings was primarily in the herrings category caught in the East Central Pacific with

lesser gains in the miscellaneous category in the West Central Atlantic.

Changes in the volume of the U.S. catch are, as indicated, more varied. These include a shift in the tuna catch from the Eastern to the Western Central Pacific, a key increase in the Northeast Pacific (pollock), as well as increased in salmon in the Pacific and herrings in the Atlantic.

From the perspective of an economist, the existing state of the FAO classification of areas and species used in this paper and elsewhere is not satisfactory. Without a careful review of the problems in the collection, classification of, and cost of this data no one can say how an optimum classification scheme for purposes of economic analysis could be constructed and ordered. However, given the most important institutional change in ocean management in four centuries (the creation of EEZ's), the role of fishery products in trade and in providing protein, this would seem to be an approproiate time to examine the utility of the organization and the accuracy of the basic data that is available on worldwide landings.

Table 5.—Change in gross revenue of North American fisheries[1].

Millions of metric tons			Millions of U.S. dollars
(1) Quan(70/72)	(2) Quan(83/85)	(3) Q2-Q1	(4) Change in total revenue
1.19	1.30	0.11	200.89
2.74	4.54	1.80	956.72
0.37	1.01	0.64	187.55
36.74	43.34	6.60	1,345.16

$\bar{X}1$ = Average catch for period 1970/72 by country.
$\bar{X}2$ = Average catch for period 1983/85 by country.
$\bar{X}2 - \bar{X}1$ = Change in average catch 1983/85 - 1970/72.

Change in total revenue 1983/85 – 1970/72. Equals change in quantity for each species times species price, summed over all species.

[1]Source: FAO Yearbook of Fishery Statistics. Prices are U.S. prices for 1985 and are obtained from Fisheries of the United States, U.S. Department of Commerce.

Table 6.—Index of present value of stocks (source: Table 5).

Nation	TR(1983-85) less TR(1970-72) U.S. dollars)	Net Present Value[1] (Millions of U.S. dollars)
Canada	200.9	1,357.9
United States	956.7	6,466.4
Mexico	187.6	1,268.1

[1]Note: NPV calculations assume discount rate of 10% and a 10-year horizon. Revenue gain is assumed to take place immediately.

Revenue

The three countries gained substantial benefits from the extension of jurisdiction. Collectively, in U.S. dollars at 1985 prices, the gross value of their catch increased by over $1 billion (Table 5). The United States accounted for the major share of the increase in gross revenue, but both Canada and Mexico increased the economic yield from their fisheries by around $200 million.

If we make an heroic assumption that gross revenue is equal to net, that is, that there are zero production costs, we can extend the gross revenue data into a crude index of the value of the stocks (the assets) acquired by the creation of EEZ's (Table 6). This approach provides limited insight into both the flow of income from fisheries and the value of the assets that generate the flow. These initial calculations are both indicative of the data problems inherent in measuring income and the basis for a crude ordering of the economic results of creation of EEZ's.

The numbers suggest that the value of the stocks of fish acquired by Canada and Mexico are greater than $1 billion. For the United States the number is in excess of $6 billion.

If we reflect for a moment on this enclosure process on a worldwide basis, we see that the creation of EEZ's involved a substantial redistribution of income and assets probably in the direction of greater international inequality.

Short Run—Long Run: Fishery Dynamics

The common property hypothesis suggests that in long-run equilibrium, the industry would have redundant capital and labor. The redundance is linked to the stability in a sustainable level of output and the price of fish. The short-run interaction of dynamic changes and the standard assumptions about long-run equilibrium, in a special case, have been noted by Pontecorvo (1986).

The elements in this model involve:

1) A shock that disturbs the initial equilibrium. A shock may be an increase in demand (increase in real price and therefore profitability), an increase in supply (more fish at constant or lower costs), technological change, expectations of future profitability (such as those expectations engendered by the advent of EEZ's), or all of the above. These shocks serve to increase short-run profits, or expectations of those profits.

2) Given profitability and easy entry, investment increases, and capital and labor enter.

3) Given supply-side limitations and a limit in the short-run to market-size, capital and labor become redundant, and profitability declines. With the asymmetry between entry and exit over some time-horizon, the industry requires government intervention to protect both capital and labor.

4) These short-run changes take place in a system where, over any long time period, demand grows with both income and changes in taste and the supply of fish protein is limited. In the long run, these forces bring about an increase in the real price of fish and the fishery again becomes profitable. In due time the short-run forces repeat the cycle.

This paper can only suggest the importance of the linkages between the long-run/short-run forces in fisheries and the underlying forces of business cycles and national economic growth. Here we can only comment briefly on a subset of these larger issues: the question of productivity change in the industry. The National Marine Fisheries Service provides data on the

Table 7.—U.S. input-output relationship[1].

Item	No. of fishermen	Percent change	No. of Vessels	Percent change	Total U.S. catch	Percent change
Average of 1970-72	140,016		14,023		2,737,833	
Average of 1983-85	230,833	+64.9%	23,133	+65.0%	4,538,291	+65.7%

[1]Data preliminary, 1978 on; 1977 data: Vessels = 17,517; tonnage = 76,350 = 44 tons per vessel.

Table 8.—Relationship between fisheries capital stock and productivity.

Item	Capital stock in U.S. fisheries	Nonfarm productivity in U.S. (output per man-hour)	Effictive U.S. fisheries capital stock[1]	Effective[2] U.S. fisheries capital stock if 25% excess capacity in 1970-72
Average of 1970-72	[3] 100/14,023[4]	[3]100	[3]100/14,023	125/17,529
Average of 1983-85	165/23,133	112	177/24,821	221/31,026
Indicated excess capacity in light vessels			1,688	7,893

[1]Effect on U.S. fisheries capital stock of increased productivity during time period.
[2]Large base (125) because of excess capacity. Growth to (1983-85) takes increased productivity growth into account.
[3]Index numbers, 1970-72 = 100.
[4]Actual number of vessels in the United States.

number of fishermen and vessels.[2] These data suggest constant returns during this time period (Table 7). The number of fishermen increased by 65 percent, and output by 66 percent.

Assume that in the period 1970-72 the fisheries were efficient, i.e., 1970-72 output was achieved at minimum cost. Assume also that, subsequently, productivity in fisheries grew at the same rate as the U.S. nonfarm economy. Given these assumptions, the stock of capital available in the fisheries in 1983-85 was larger than indicated by the amount of the growth in the quantity of capital, i.e., the number of vessels.

In other words, by 1983-85 the observed constant relationship between output and capital concealed the presence of more than 1,600 redundant vessels (Table 7). If we further assume 25 percent excess capacity in 1970-72 then the condition of the U.S. fisheries is significantly worse when we reach 1983-85; i.e., there were almost 8,000 redundant vessels (Table 8).

In this context, "worse" has several meanings. It suggests less efficient use of resources; i.e., the presence of redundant capital and labor relative to the level of output. Worse is also a proxy for increased risk in the industry. All industries and firms are linked to business cycles and therefore are at risk of financial collapse with changes in demand, interest rates and other costs. These risks tend to be higher with small firms with few financial resources and options.

If an industry is inefficient, cyclical fluctuations in earnings have an increased impact on the viability of firms. Also, if the industry is subject to supply shocks, resulting from instability in the underlying fish populations and ecosystems, risk is increased further. Therefore, in the short run, fisheries tend to be subject to the usual economic risks plus the risk of supply side shocks and the risks inherent in redundant capacity.

Underlying the productivity issue, business cycles, economic growth, and stock instability problems are a set of empirically interesting questions involving capital, labor, and technological change.

In the United States:

1) What has happened to technological change and productivity as expressed in the average size and quality of vessels over this period? Has there been a change in vessel size and performance since the early 1970's? Has the introduction of sophisticated electronic devices increased productivity and safety? Is it reasonable to assume that both the quality and quantity of capital have increased over this time horizon and that these changes in technology have particularly increased productivity? If this is the case then an index of productivity change plus the additions to capital should reveal a declining catch per ton.

2) A similar set of questions involve the human capital in U.S. fisheries. Is there reason to believe that conditions of employment and experience have contributed to the creation of more efficient and skilled labor?

[2]Parts of the time series on vessels were provided to me by personal communications. Capital on vessels is broken down into vessels (5 net tons and over), data on motor boats, and other boats. Here I have used only vessels. In 1977, adjusted for sailboats, the 17,517 vessels had an average of 44 tons per vessel. The last year for which this data is available is 1977, and therefore one cannot tell if there has been any change in the distribution of vessel size. This is potentially important if one assumes links between size and productivity of capital. Suggestions about productivity changes over time are discussed below.

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U.S. Fisheries Management and Foreign Trade Linkages: Policy Implications for Groundfish Fisheries in the North Pacific EEZ

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The groundfish resources of the U.S. Exclusive Economic Zone (EEZ) off Alaska, dominated by Alaska or walleye pollock, *Theragra chalcogramma*, Pacific cod, *Gadus macrocephalus*, and flatfishes, *Pleuronectidae*, can sustain annual commercial harvests well in excess of 2 million metric tons (t). As recently as 1979, foreign fisheries took 99 percent of the annual harvest supported by these resources. This has changed dramatically during the 1980's. The foreign fisheries have received rapidly decreasing allocations, first as joint venture fisheries expanded and, more recently, as the domestic fisheries have grown. Joint venture fisheries are fisheries in which domestic fishing vessels deliver their catch directly to foreign processing vessels in the EEZ. By 1986, the joint venture and domestic fisheries accounted for 66 percent and 8 percent, respectively, of the annual harvest. The preliminary corresponding figures for 1987 are 78 and 18 percent.

The development of the wholly domestic fisheries, which may replace both the foreign and joint venture fisheries during the next several years, has initiated an era in which fishery management and international trade issues will be much more closely linked than they have been in the past. This is due, at least in part, to the differences between the markets for groundfish and the markets for the species that the U.S. domestic fisheries off Alaska have traditionally exploited. These differences are the topic of this paper.

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Alaska Fisheries Mainstays

King crab, *Paralithodes* spp., Tanner or snow crab, *Chionoecetes* spp., Pacific halibut, *Hippoglossus stenolepis*, and the five species of Pacific salmon, *Oncorhynchus* spp., have been the mainstays of the domestic fisheries off Alaska for many years, and will remain an important and perhaps the dominant part of these fisheries, even when the groundfish resources are fully utilized by the wholly domestic groundfish industry. Alaska has been the predominant source of these species in both domestic and international markets. A high degree of product differentiation has been developed for these species, and most have relatively high prices and are regarded as luxury goods. Therefore, there are often very limited alternative supplies and other species are often not perceived to be close substitutes for them.

There are several reasons why these market characteristics are desirable from the perspective of those who supply fishery products. First, the supply from other sources may not be sufficient to be a major source of uncertainty or instability regarding product price. Second, the demand for the product will tend to be less elastic with respect to its price (i.e., the price may be relatively responsive to a change in supply); therefore, reductions in catch caused by a decrease in a harvest quota will be significantly, if not more than completely, offset by an increase in price. (Note that the stability of total revenue, with respect to changes in output, increases as the price elasticity of demand approaches unity, and then decreases as the elasticity continues to decrease beyond unity.) Third, increased costs can be passed on by increasing product price, with only a relatively small decrease in the amount that can be sold. Fourth, as the traditional supplier of the species, the Alaska seafood industry has established itself as a reliable source of product of known quality and the markets for these products are well understood by those in the industry. The result is, the Alaska seafood industry can often command a premium price for its product, while simultaneously incurring relatively low marketing costs.

Groundfish Market Characteristics

The market characteristics are quite different and relatively unfamiliar in the case of the principal Alaska groundfish species, such as Alaska pollock and Pacific cod. Alaska is an important but certainly not dominant source of supply of products derived from these species. There appear to be close substitutes in the marketplace for cod, flatfishes, and pollock from Alaska. Moreover, the Alaska seafood industry is a relative newcomer to many of these markets, and has not as yet fully established itself as a reliable source of product of known quality. These market characteristics are much less desirable from the perspective of

those who supply fishery products.

First, the supply of these products from the rest of the world is large enough to significantly affect the prevailing market price. This source of uncertainty is much greater for groundfish than it has been for the traditional Alaska species. Second, prices may be relatively unresponsive to changes in the quantity supplied by Alaska fisheries. Therefore, when output is decreased by a reduction in a quota, revenue may decrease almost proportionally. Third, increased costs will, to a great extent, have to be absorbed by the domestic groundfish industry, because even a small price increase could result in a large decrease in the amount of groundfish that the industry can sell. Fourth, to establish itself in these new markets, the industry will often have to offer a lower price than the established suppliers, and incur higher marketing costs, at least for a period of time.

The following examples present two cases in which fishery management and international trade issues are closely linked because of the characteristics of the groundfish markets. They also demonstrate why these two aspects of public policy will be increasingly important in conjunction with one another, as the management of the U.S. EEZ evolves and matures. An important management issue, particularly in the Alaska fishing sector, is that of establishing regulatory measures that encourage and facilitate the development of shore-based processing capacity. Because the U.S. domestic groundfish industry will tend to be a price taker, rather than a price setter, two questions concerning international trade are relevant: Are the types of operations which are being encouraged economically viable, given current world prices, and will they be, given the prices expected over the next several years? Well-informed expectations will be based on an understanding of international trade issues, including tariff negotiations, temporary shortfalls or increases in world supply, and alternative sources of product.

Another fishery management issue that requires international trade information for an informed decision is the determination of the appropriate allocation of surplus resource to the remaining foreign fisheries operating in the U.S. EEZ. The appropriate quotas depend on a variety of factors, such as the response of the resource to exploitation at the established quota levels, the rate at which the domestic fisheries are expected to develop, and the effects of the foreign quotas on that development. Both the second and third factors are affected by international trade considerations. Concern about the influence of foreign participation in directed fisheries on domestic groundfish development was, for example, an important mitigating factor when the North Pacific Fishery Management Council established the 1987 total allowable level of foreign fishing (TALFF) for Pacific cod. The paper that was prepared by the National Marine Fisheries Service for the Council, to help it make an informed decision concerning this TALFF allocation, included the following types of international trade information:

1) Annual foreign cod harvests from the U.S. EEZ off Alaska,
2) Trends in the production of cod and cod-like species from other sources,
3) U.S. imports of cod and cod-like products by product form,
4) Wholesale and import price trends for cod,
5) Trends in cod and cod-like imports by country for several major importing nations and,
6) Trends in Japanese prices for cod and cod-like products.

There was, unfortunately, insufficient data available with which to definitively determine the extent to which foreign directed allocations of Pacific cod affect the ability of U.S. domestic fishermen to market cod. However, the following preliminary findings were made.

Preliminary Findings

The foreign directed fisheries take a large, but not dominant, share of the Pacific cod catch in the U.S. EEZ, off Alaska. Between 1982 and 1986, the annual foreign harvest ranged from 55,100 t in 1986 to 74,400 t in 1984 and averaged 64,400 t. During this same period, domestic vessels participating in domestic and joint venture fisheries had annual harvests which increased steadily from 55,100 t in 1982, to 107,800 t in 1986 and averaged 76,200 t. For this 5-year period, as a whole, the foreign fisheries accounted for 45.8 percent of the total cod catch. By 1986, they accounted for only 33.8 percent of the catch of Pacific cod in the U.S. EEZ off Alaska.

Similarly, the U.S. EEZ is an important, but not predominant, source of Pacific cod in the world marketplace. Food and Agriculture Organization of the United Nations (FAO) statistics for 1982 through 1985, indicate that the total world catch of Pacific cod increased steadily from 239,200 t in 1982 to 409,600 t in 1985, with most of the growth occurring outside the U.S. EEZ. By 1985, only 38.7 percent of the total world catch of Pacific cod was taken in the U.S. EEZ.

The development of the U.S. domestic Pacific cod fishery, to a significant extent, has depended upon the ability of the domestic factory trawl fleet to market Pacific cod as a substitute for Atlantic cod. This suggests that, in determining the impact of a change in the foreign allocation of Pacific cod in the North Pacific EEZ, it is appropriate to consider the world supply of the Atlantic cod as well as the Pacific cod. Although Pacific cod has become relatively more important as the result of increasing harvests of Pacific cod and decreasing harvests of Atlantic cod in the last few years, Atlantic cod remains the dominant species. As a percentage of Atlantic and Pacific cod catch, Pacific cod increased steadily from 9.6 percent in 1982 to 17.4 percent in 1985. During this period, the total world production of these two species varied from 2.4 to 2.5 million t.

Like the Pacific cod fishery, the development of the U.S. domestic

Alaska pollock fishery has, at least in part, been dependent upon the ability of harvesters to market Alaska pollock as a substitute for cod. This suggests that, within the cod family, there are a number of substitutes for Pacific cod. FAO statistics indicate that the world catch of cods, hakes, and haddocks increased almost without interruption from 10.6 million t in 1982 to 12.4 million t in 1985. Although there are several reasons why all of this catch does not compete in world markets with Pacific cod harvested from the U.S. EEZ, a large enough part of it does that changes in Pacific cod quotas or foreign allocations in the EEZ are not expected to have a significant effect on the ability of U.S. producers to compete in most markets, including the large U.S. domestic market.

The U.S. Market

With respect to the domestic market, the United States is the world's largest importer of frozen processed groundfish product. U.S. groundfish imports, for all species, account for about 70 percent of the total world volume of trade in these commodities. Clearly, the United States is a major market for cod and cod-like products. Between 1982 and 1986, U.S. imports of groundfish products, including fillets, steaks, blocks, and both dressed and whole fish, consisting primarily of cod and cod-like products, ranged from 732 to 837 million pounds, product weight (Tables 1, 2). The average annual imports of 793 million pounds, or 360,000 t, had a live weight equivalence of approximately 1.1 million t.

A second measure of the size of the U.S. market, especially for cod and cod-like products, is provided by estimates of U.S. consumption of fish fillets, steaks, sticks, and portions. The consumption of these products, which are dominated by cod and cod-like species, increased from 988 million pounds in 1980, to 1,211 million pounds in 1986 (Table 3). The live weight equivalence for 1986 would have exceeded 3.1 billion pounds, or 1.4 million t.

A third indication of the current strength of the U.S. cod market is provided by price trends (Table 4). Wholesale prices for most cod products have been characterized by increases in annual averages since the early 1980s, and by monthly prices for 1987 typically above their counterparts for 1986 (Table 5). However, some cod prices decreased after reaching record highs in early 1987.

Japan was the principal alternative market for Pacific cod from the U.S. EEZ and became the focus of much of the public debate concerning the impact on domestic fisheries of foreign allocations of Pacific cod in the EEZ off Alaska. The dollar price of cod in Japan has displayed a trend similar to those, described above, in the U.S. market. Japanese monthly prices in 1987 were typically above the 1986 monthly levels, and a near record high price was recorded in early 1987 before prices fell (Table 6). The yen price of cod did not display the same trend because of the drop in the exchange rate during 1987.

The similarities in price trends indicate that there is a linkage between U.S. and Japanese prices. That linkage does not, however, demonstrate that the price relationship is causal, as

Table 1.—U.S. imports[1] of groundfish fillets, steaks, and blocks, 1976-86.

	Fillets and steaks		Blocks		Total	
Year	Amt.[2]	Value[3]	Amt.[2]	Value[3]	Amt.[2]	Value[3]
1976	337	273	379	211	716	484
1977	321	305	385	292	706	597
1978	333	341	406	325	739	666
1979	340	385	408	337	748	722
1980	297	341	336	289	633	630
1981	346	415	344	301	690	716
1982	371	458	319	274	690	732
1983	355	449	384	339	739	788
1984	373	459	316	263	689	722
1985	388	500	334	275	722	775
1986	366	542	364	380	730	922

[1]Sources: U.S. Dep. Commer. Bur. Census, Wash., D.C., and Natl. Mar. Fish. Serv. database avail. from Northwest Alaska Fish. Cent., 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115-0070.
[2]Quantity (Amt.) in millions of pounds, product weight.
[3]Value in millions of dollars.

Table 2.—U.S. imports[1] of whole or dressed groundfish, 1976-86.

	Canada		Other		Total	
Year	Amt.[2]	Value[3]	Amt.[2]	Value[3]	Amt.[2]	Value[3]
1976	13.935	4.932	4.526	6.216	18.461	11.148
1977	11.701	4.330	4.294	5.598	15.995	9.928
1978	10.659	4.115	4.248	5.838	14.907	9.953
1979	15.682	6.175	5.965	8.902	21.647	15.077
1980	16.402	6.617	2.668	5.243	19.070	11.860
1981	28.908	12.090	3.577	7.107	32.485	19.197
1982	38.342	14.215	3.487	7.006	41.829	21.221
1983	48.941	18.117	4.183	7.072	53.124	25.189
1984	80.882	30.029	4.773	7.334	85.655	37.363
1985	99.174	37.538	5.214	8.793	104.388	46.331
1986	99.521	47.703	7.886	12.499	107.407	60.202

[1]Sources: U.S. Dep. Commer. Bur. Census, Wash., D.C., and Natl. Mar. Fish. Serv. database avail. from Northwest Alaska Fish. Cent., 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115-0070.
[2]Quantity (Amt.) in thousands of pounds, product weight.
[3]Value in thousands of dollars.

Table 3.—U.S. consumption[1] of all fillets and steaks, and fish sticks and portions, 1980-86.

	Fillets and steaks		Fish sticks and portions	
Year	Total[2]	Per capita[3]	Total[2]	Per capita[3]
1980	545,347	2.40	442,892	1.95
1981	564,844	2.46	414,149	1.80
1982	582,630	2.51	400,455	1.73
1983	649,828	2.77	413,858	1.77
1984	713,159	3.02	430,895	1.82
1985	776,093	3.25	419,547	1.76
1986	780,201	3.24	431,266	1.79

[1]Source: Computed from data from U.S. Dep. Commer. Bur. Census, and Natl. Mar. Fish. Serv. "Fisheries of the United States," var. iss.
[2]Total in thousands of pounds, product weight.
[3]Per capita in pounds ("Total" divided by total U.S. resident population.

Table 4.—Annual wholesale prices[1] of selected frozen fish blocks and fillets, f.o.b. east coast, 1976-86, in cents per pound.

	Blocks			Cod fillets		
Year	Cod	Minced cod	Alaska pollock	Bone-in, Canada	Boneless, Canada	Boneless, Iceland
1976	74.1	31.1	43.0	71.7		111.2
1977	97.8	36.1	60.7	91.1		126.7
1978	100.0	37.7	68.6	90.5		130.0
1979	103.9	50.4	68.8	88.5		155.0
1980	105.6	51.8	69.5	89.4		160.0
1981	109.2	51.1	80.5	108.0		172.3
1982	110.9	51.3	72.4	103.6	127.5	180.0
1983	116.9	39.9	65.6	100.9	126.5	180.0
1984	104.0	30.4	67.9	98.0	130.0	180.0
1985	110.6	45.9	58.0	104.9	125.6	180.0
1986	141.7	60.5	78.9		165.0	196.4

[1]Source: Fishery Market News Report, Natl. Mar. Fish. Serv. 408 Atlantic Ave., Boston, MA 02210-2203.

Table 5.—Monthly wholesale prices[1] of selected frozen fish blocks and fillets, f.o.b. east coast, 1985-87, in cents per pound.

	Blocks				Fillets			
Year/ mo.	Cod	Cod, minced	Alaska pollock	Whit- ing	Cod, Canada	Cod, Iceland	Floun- der	Ocean perch
1985								
Jan.	104.0	36.2	66.9	63.0	125.0	180.0	177.5	102.5
Feb.	104.0	40.0	67.0	63.0	125.0	180.0	177.5	NQ[2]
Mar.	104.0	41.5	67.0	63.0	125.0	180.0	177.5	105.0
Apr.	104.0	42.5	NQ	62.5	125.0	180.0	177.5	107.5
May	104.0	43.5	65.5	63.0	127.5	180.0	177.5	107.5
June	103.0	43.5	65.5	62.5	122.5	180.0	180.0	107.5
July	107.0	45.0	63.0	62.5	120.0	180.0	177.5	107.5
Aug.	110.0	45.5	NQ	62.5	120.0	180.0	180.0	107.5
Sept.	112.0	49.0	61.0	62.5	122.5	180.0	182.5	107.5
Oct.	119.0	52.0	61.5	62.5	125.0	180.0	182.5	107.5
Nov.	125.0	54.0	61.5	63.0	135.0	180.0	180.0	NQ
Dec.	130.0	57.0	62.5	63.0	140.0	180.0	185.0	122.5
1986								
Jan.	132.5	57.0	62.5	62.5	140.0	180.0	185.0	122.5
Feb.	135.0	59.0	64.0	62.5	145.0	180.0	185.0	122.5
Mar.	135.0	60.0	65.0	62.5	145.0	180.0	185.0	NQ
Apr.	135.0	61.0	67.0	62.5	150.0	185.0	185.0	NQ
May	135.0	61.0	67.0	62.5	147.5	185.0	185.0	135.0
June	135.0	61.0	70.0	63.5	142.5	190.0	185.0	137.5
July	140.0	61.0	NQ	66.5	150.0	190.0	185.0	137.5
Aug.	145.0	61.0	84.0	69.0	165.0	197.0	185.0	137.5
Sept.	150.0	61.0	91.0	73.0	175.0	205.0	185.0	150.0
Oct.	150.0	61.0	95.0	75.0	192.5	205.0	187.5	155.0
Nov.	150.0	61.0	98.0	81.0	207.5	230.0	187.5	152.5
Dec.	157.5	61.0	104.0	81.0	222.5	230.0	192.5	160.0
1987								
Jan.	160.0	61.0	105.0	87.5	225.0	230.0	190.0	157.5
Feb.	170.0	57.0	109.0	93.5	227.5	245.0	197.5	157.5
Mar.	172.5	54.0	107.0	97.5	227.5	245.0	197.5	152.5
Apr.	175.0	51.0	104.0	95.0	222.5	245.0	197.5	152.5
May	180.0	49.0	103.0	96.5	200.0	245.0	197.5	150.0
June	187.5	NQ	103.0	96.0	212.5	247.5	197.5	NQ
July	195.0	53.5	105.0	97.5	212.5	247.5	195.0	162.5
Aug.	200.0	55.0	105.0	100.0	212.5	247.5	200.0	NQ
Sept.	200.0	55.0	105.0	100.0	215.0	247.5	200.0	162.5
Oct.	200.0	55.0	105.0	100.0	212.5	247.5	207.5	NQ
Nov.	200.0	58.0	103.0	99.0	195.0	247.5	207.5	147.5
Dec.	200.0	59.0	99.5	99.0	187.5	247.5	207.5	147.5

[1]Source: Fishery Market News Report, Natl. Mar. Fish. Serv., 408 Atlantic Ave., Boston, MA 02210-2203.
[2]NQ = No quote.

Table 6.—Monthly Tokyo wholesale prices[1] of frozen cod, 1982-87, in yen per kilogram, and dollars per pound.

	Wholesale price											
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Yen per kilogram											
1982	292	363	267	287	302	370	334	327	347	421	367	325
1983	304	329	391	443	391	382	322	355	400	397	415	443
1984	477	410	404	349	416	377	378	452	470	458	434	429
1985	433	483	344	340	374	318	444	386	413	351	416	423
1986	431	434	404	382	371	402	376	395	432	466	436	518
1987	486	384	365	404	398	352	444	433	464	552	557	418
	Dollars per pound											
1982	0.59	0.70	0.50	0.53	0.58	0.67	0.59	0.57	0.60	0.70	0.63	0.61
1983	0.59	0.63	0.75	0.85	0.76	0.72	0.61	0.66	0.75	0.77	0.80	0.86
1984	0.92	0.80	0.81	0.70	0.82	0.73	0.71	0.85	0.87	0.84	0.81	0.78
1985	0.77	0.84	0.60	0.61	0.67	0.58	0.83	0.74	0.79	0.74	0.93	0.95
1986	0.98	1.07	1.02	0.99	1.01	1.09	1.08	1.16	1.27	1.36	1.22	1.45
1987	1.43	1.13	1.09	1.28	1.28	1.10	1.34	1.33	1.47	1.74	1.87	1.47

[1]Sources: Monthly Stat. Agric., Forestry, Fish., Stat. Info. Dep., Minist. Agric., Forestry, Fish., Gov. Jpn.; Foreign Fish. Inf. Release, Natl. Mar. Fish. Serv., 300 S. Ferry St., Terminal Isl., CA 90731.
[2]Weighted average price.

argued by some opposed to foreign allocations. Rather, the linkage is better explained by the observation that both countries appear to be price takers in the much larger, integrated world market for cod and cod-like products. That is, prices in both countries are principally determined by events and policies which neither country controls.

This analysis does not suggest that opportunities for U.S. producers to export cod to Japan are independent of allocations of Pacific cod to Japanese fishing fleets. What it does suggest is that the opportunities to sell cod in general are not adversely impacted.

This conclusion, which at first may appear to be inconsistent, is easily explained. At a given price, which is determined by the world market for cod and cod-like products, there will be a fixed amount of cod that can be marketed in Japan. Due to actual or perceived differences in quality, or for other reasons, there will be a tendency for imports to equal that amount, minus the catch from Japanese vessels. That is, imports will be used to meet whatever demand is not met by Japanese producers. Therefore, everything else being equal, Japanese imports would be expected to decrease as Japanese catch increases. However, since Japanese catch is not expected to affect world prices (nor U.S. domestic prices), unchanged opportunities to market cod domestically at comparable prices remain. This being the case, those who only have access to the Japanese market would be adversely affected by allocations of surplus (unutilized) Pacific cod to Japan. It is possible that, in the short run, vessels equipped only to produce headed-and-gutted product may be in this category. In the longer run, one would expect adjustments to be made within this segment of the domestic industry to ameliorate this situation.

Profitability

There are a number of factors which make the cod fishery more profitable than it has been in the past, or perhaps than it will be in the not too distant future. First, Pacific cod stocks in the

EEZ off Alaska are in a state of abnormally high abundance, resulting in higher levels of catch per unit of effort, than can be expected on average. Second, the exchange rates between the U.S. dollar and many foreign currencies are at low levels, making U.S. cod products more competitive in both domestic and international markets. Third, there is at least a short-term reduction in the productivity of Atlantic cod stocks, which has tended to hold prices above normal levels. Fourth, the continued growth of the U.S. economy increases the demand for cod and other fishery products. When that growth ends and the economy enters the next recession, consumers will pay more attention to the prices of fish relative to poultry and red meat, and less attention to the perceived health benefits associated with consumption of fishery products. The demand for, and the price of, fishery products like cod will decrease, or at least increase less rapidly than they have in recent years. A similar scenario can be expected in the other major markets for cod and cod-like species as, for example, the western European and Japanese economies follow this same economic trend. Finally, as the U.S. domestic harvesting and processing sectors of the Pacific cod fishery become overcapitalized, as they undoubtedly will in response to the open access nature of this fishery, resources used in these fisheries will not be able to be fully and efficiently employed, and cost per unit of product will increase.

These factors, taken together, suggest that within the next few years a reasonable expectation is that decreases in price, and increases in production costs, will reduce the profitability of the domestic Pacific cod fishery, perhaps significantly. In light of this expectation, it seems appropriate to counsel caution in regard to the initiation of economic activities and capital investments that are marginally profitable under the present extraordinarily favorable economic circumstances.

Clearly, many of the hypotheses put forth in this analysis await rigorous empirical evaluation. The U.S. trade database and the foreign country trade database, maintained by NMFS, provide much of the information needed for such research. Enhancement of these databases, as well as acquisition of other sources of world groundfish production, trade, and market data, will be required to improve our understanding of the linkages between foreign trade and fishery management issues.

Research in Global Groundfish Markets: An Exercise in International Cooperation

LEWIS E. QUEIROLO and RICHARD S. JOHNSTON

Introduction

Over roughly the last decade, most of the fishery resources of the continental shelf and nearshore areas of the world's oceans have come under the control of coastal nations. One consequence of this extension of fisheries jurisdiction (EFJ) by any individual state has been the expansion of its production possibilities. That is, with strengthened property rights in the ocean resources off its shores, a coastal nation experiences increased opportunities to produce goods and services from its newly enlarged pool of resources. Such a nation, then, would appear to be a potential gainer from EFJ.

On the other hand, one would tend to identify as "losers" those countries whose distant-water fleets fished in those same waters prior to EFJ, especially if their access to these waters were restricted by the new "owners." Thus one would expect to see new production levels, new patterns of international trade, and new institutional structures (i.e., management regimes, international cooperative arrangements) to emerge from EFJ. In this paper we explore some of these issues from a conceptual point of view and briefly describe a research project designed to test several of the hypotheses that emerge. Our theme is that EFJ has not only spawned new international relationships in the commercial and public sectors; it has also provided incentives to cooperate internationally in research activity. Fear of the cost of disclosing valuable information to potential foreign competitors appears to be overshadowed by the recognition of potential benefits from new insights to be gained through shared research experience. Our laboratory is the world groundfish fishery.

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EFJ and Production Possibilities

Consider the coastal nation that has declared an EFJ zone. There are two sources of increased production available to it. The first is associated with expanded production possibilities through increased ownership claims to resources. (In the parlance of the economist, this is characterized as an outward shift in the production possibilities frontier.) The second is through more efficient use of resources which, prior to EFJ, were characterized by open access, or "common property," conditions (Anderson, 1986). As suggested above, this would appear to be a reasonably clear-cut case of potential gain for the coastal state initiating the EFJ zone. That is, with the resulting increases in output, the country's real income should rise.

However, there are exceptions. The literature on economic growth suggests that expanded production, if it is concentrated in a nation's export sector, may so depress the prices of the products whose output has been expanded that the country's real income declines, a case of "immiserizing" growth (Bhagwati, 1958; Johnston and Siaway, 1985). While the redistribution of resources is, in itself, unlikely to affect total production directly,[1] the more efficient use of those resources afforded by new managerial authority could raise production sufficiently to induce prices to fall enough to effectively convert a "gainer" country into a "loser" country. Whether this, in fact, occurs depends to a large degree on 1) what happens to production and 2) prevailing price elasticities of demand. If, for example, a coastal country is a net exporter of groundfish and faces a highly price-inelastic export demand, increased production may lead to an abrupt deterioration in its prevailing terms of trade. Knowledge of price elasticities of demand for groundfish then, is of more than passing academic interest in such circumstances.

Furthermore, even if groundfish management in any one country did not have such an impact on prices, effective implementation of management measures on a global scale could lead to the same result, a case of pecuniary externalities. This raises additional empirical questions calling for resource assessment and improved understanding of the characteristics of both groundfish demand and supply response. For any country forecasting the consequences of its own management strategies, there will also be an interest in the cost of management.

Let us now turn our attention to the other side of this issue. That is, what of the impact of EFJ on a country whose distant-water fishing fleets have been moved away from their "traditional" fishing grounds? Here the case would appear to be less ambiguous.

[1]If it did, a version of the "transfer problem" could arise, in which terms of trade are affected by a change in output following a transfer of resources from one country to another, resulting in adverse effects on the recipient country. For fishery resources this is unlikely in the short run. As alternative uses of the oceans are explored (e.g., ocean mining), this could emerge as a long-run consequence of EFJ, however. R. W. Jones. 1975 Presumption and the transfer problem. J. Int. Econ. 5:263–274.

Denied access to resources, such a country must surely experience a loss in real income. Even under these circumstances, however, the situation is far from clear. Even in the absence of various cooperative possibilities designed to regain at least partial access (a topic explored in a later section of this paper), such a country may find that EFJ has actually resulted in the opportunity to import groundfish at a price below its own unit cost of production.[2] This could result from increased output accompanying management (outlined above) and a consequent decline in price. Just as growth may effectively work against the growing country, so may contraction actually favor the contracting country, although the argument is not symmetrical. That is, we are not suggesting that EFJ would lead to an increase in the price of groundfish, so that an exporting country with fewer resources could be made better off. Because the resources are being transferred to other producers, prices could fall, but are unlikely to increase. Again, the question calls for empirical research on production possibilities, demand elasticities, and the trade position of the market participants. Growth would not be "immiserizing," in the sense described above, for a coastal country which was a net importer of groundfish and which gained groundfish resources through EFJ. Such a country could always return to pre-EFJ fishing patterns. Similarly, a country whose distant-water fleets produced groundfish for export would not likely gain from forced exodus from groundfish resources, unless it continued to be an exporter and simply experienced a lower cost of inputs from importation than from own-production.

[2]Perhaps as a result of a successful "infant industry" argument by the coastal state and the emergence of a low-cost domestic industry in the new EEZ. Indeed, an often overlooked dimension of the infant industry argument for short-term protection from foreign competition is that, if the infant matures, gains may accrue to countries in addition to the one protected. G. R. Munro. 1982. Cooperative fisheries arrangements between Pacific coastal states and distant water nations. *In* H.E. English and A. Scott (editors), Renewable resources in the Pacific, Proceedings of the 12th Pacific Trade and Development Conference, 7–11 September 1981, Vancouver, B.C., Can. Int. Develop. Res. Cent., Ottawa, Ont., Can., p. 247–254.

From Potential to Actual Gains

Coastal States

In the previous section, we argued that there may be potential gains to coastal countries establishing EFJ zones, although there also exists the possibility that terms of trade effects convert gains into losses. Consider the case where real gains could be realized and where decision-makers have a number of options from which to choose in capturing these gains.

Economists have explored several dimensions of this issue. Munro (1985) pointed out that, whereas sentiments a decade ago favored exploiting the resource exclusively by the fleets and processors of the newly endowed coastal nation (perhaps by phasing foreign distant-water fleets out of the coastal country's exclusive economic zone), there is now consensus that some foreign participation may make sound economic sense to the coastal country, even on a long-term basis. The latter position rests on comparative advantage notions under which, if costs of production, harvesting, and/or marketing are lower for the distant-water fleet(s) than for the coastal country, over some range of output, all participants could gain if the coastal country "imported" those services in which it has a comparative disadvantage.

Johnston and Wilson (1989) extended the argument to include the possibility that managerial services could be more efficiently provided by foreign nations than by the coastal state, especially if the visitor shared in the resulting rent and, thus, had an incentive to manage the resource optimally. As pointed out by Hemmi (1982), however, all such "free trade" arguments rest on conditions of full information by all parties, a point to which we turn below.

Several economists have focused on the design of structures that will maximize net benefits to the individual coastal country. Chen and Hueth (1983:461), for example, examine the welfare implications of various joint venture arrangements in a paper "concerned with determining an allocation which maximizes the potential economic benefits to the U.S."

At the conceptual level, then, some attention has been given to how the coastal country can take advantage of its newly-acquired resources. To quote Munro (1985:272), ". . .if there is to be a distant water nation presence within the coastal state's EEZ over the long run, then it must be because it is in the selfish interest of the coastal state for there to be such a presence." Design of the appropriate policy calls for empirical estimates of costs of harvesting, processing, marketing, and management (surveillance and enforcement) by the coastal country, in order to compare these with offers to supply these services by foreign countries. Willingness by foreigners to pay for participation could be revealed by market devices, such as competitive bidding but, in their absence, can be estimated by empirical measures of demand for the products of the EFJ zone and potential producer surpluses abroad, as suggested by the work of Crutchfield (1983) and others.

Distant-water Fishing Nations

Much of the research in the public domain has focused on potential benefits of EFJ to coastal nations. Particular emphasis has been on problems of realizing potential gains by developing nations with newly acquired coastal resources. Little has been said about the "loser" countries, whose distant-water fleets have lost access to fishing grounds, and "optimal" strategies from their perspective. As a result, an important consequence of EFJ has been overlooked, as far as we can determine. Namely, while some distant-water fleets may suffer losses in real income as a result of EFJ, others may actually realize substantial gains.

How can this be? The answer is that some distant-water fleets may have gained from EFJ, through finding themselves competing in the marketplace, rather than on the ocean. That is, under EFJ, a distant-water fishing nation which previously faced the risk and uncertainty associated with competition for an open-access resource, may now find that, with the extension of ownership control over the resource by a third party coastal nation, operating risks, and therefore costs, have been significantly diminished. Competitive advantage at the negotiating

table may replace competitive advantage on the fishing grounds. This is the case even in the absence of positive terms of trade impacts.

It has been argued that, because of favorable endowments of capital and labor, mobility (or malleability) of capital, preferred access to markets, etc., foreign fleets may offer decided advantages to coastal countries with new exclusive economic zones (EEZ) (Munro, 1985). These advantages could be realized through various cooperative arrangements, ranging from fee fishing to joint ventures. For the distant-water nation to be willing to participate in such arrangements, it must be to its economic advantage to do so. We conjecture that, where a distant-water fishing nation holds cost or market access advantages over other competing distant-water nations, these economic advantages will more likely be realized after EFJ than before. The reason for this is that, while, in the pre-EFJ, open access fishery, cost advantages may generate inframarginal rents (Copes, 1972), these rents are smaller than could be realized through successful resource management. In the extreme, if such management calls for effort restriction, the country with the most "efficient" distant-water fleet may be the only successful bidder for participation in the post-EFJ fishery.

Even if it is only one of several distant-water participants, its share of the resource rent, when added to its inframarginal rents, could exceed its earlier net earnings. Whether this will be the case for any particular distant-water nation is an empirical question, but it is significant that Japan increased its landings by six percent between 1973 and 1985; for the Republic of Korea, the increase was an astounding 59 percent. The distant-water fishing nations of East Germany, West Germany, and the U.K. are among those whose total landings declined over this period.

Sommer (1983), has argued that, in the case of the Federal Republic of Germany, ". . .the fishing grounds of the high sea trawlers were mainly in national waters of third countries, which became inaccessible by the new law of the sea. Thus, the extension to 200 miles and catch prohibitions have had greater influence on the German fishing fleet than on any other within the EEC. . . (A) reincrease of landings . . . cannot be expected, because the limited catch quota in the EEC fishing zone and successful joint ventures will make a further reduction of the high sea fishing fleet inevitable in the near future." (pp. 284–285).

In the case of Korea, Rhee (1982:71) argued that ". . . the South Koreans exploited the profitability that existed in the fishery industry because of low wages. As soon as the developing countries obtained access to world capital for securing fishing vessels and fishing technology, they began to move into distant-water fishing." Cost advantages enjoyed by some distant-water fleets in the presence of open access conditions may have yielded even greater advantages during the post-EFJ era.

These data may or may not reflect existing or potential cost or market advantages and, thus, successful competition for access to the new EFJ zone. However, new cooperative arrangements are unfolding, as both coastal and distant-water nations explore potential gains.

Munro (1985:278), however, holds different views. He argued that, while there were costs associated with the uncertainties of competing with rival distant-water fleets in open access fisheries, " . . . this has been more than offset by negative uncertainties arising from coastal state allocation policy." He pointed out that Japan's distant-water harvests fell by almost 50 percent between 1974 and 1980, and suggested that the long-run viability of contractual arrangements between coastal states and distant-water nations requires reinvestment in distant-water fleet capacity. His arguments make sound economic sense, although we point out that the Japanese situation seems to have changed since 1980. Whether the economic forces he enumerates, or those we suggest, prevail for any given distant-water nation can be determined only by empirical investigation.

It is hardly surprising that there exists substantial interest in economic analysis of demand and cost conditions to determine the extent of the benefits from such participation. Even those countries that have "lost" from EFJ may be able to reduce these losses by exploring the costs and benefits of partnership arrangements with coastal states.

Americanization

The United States extended jurisdiction over the fishery resources adjacent to its coasts in 1976 with the passage of the Magnuson Fishery Conservation and Management Act. Since then, U.S. fisheries policy has gone through several stages, especially with respect to the nature and extent of foreign vs. wholly domestic participation. The popular term for this progression toward exclusive domestic utilization of the EEZ is "Americanization." Focusing on a single example, which is characteristic in kind if not in scale in the U.S. EEZ, we may consider the walleye or Alaska pollock, *Theragra chalcogramma*, fishery. In the current stage, foreign involvement is to be phased out, including joint-venture "over-the-side" sales of Alaska pollock to foreign processors, and the fishery is to be converted to a wholly domestic operation at the most rapid pace possible. What are the implications of the argument advanced above for this accelerated Americanization policy?

Consider the data. Over 70 percent of foreign finfish catch in 1986 in the U.S. EEZ off Alaska (the Gulf of Alaska and, more importantly, the Eastern Bering Sea), was Alaska pollock. The 1986 joint venture harvest of Alaska pollock accounted for almost 69 percent of the joint venture landings in the entire U.S. EEZ. The directed foreign fishery catch of Alaska pollock in 1984 was 1.032 million metric tons (t). By 1986, this had fallen to 353,000 t. The bulk of the landings were by Japan, with Korea a distant second. The joint venture catch of Alaska pollock in 1986 was 904,000 t, more than double its 1984 level. Again, Japan and Korea were the leading U.S. partners, in that order.

As we interpret the current U.S. attitude, in both the public and private sectors, it is that the success of the Americanization policy will depend upon the ability of the U.S. industry to supply the important Japanese markets, especially with respect to Alaska pollock. If the United States displaces the Japanese and Korean fleets and processors, will it automatically replace these countries in their respective markets? Perhaps. But not all countries with new EFJ's have adopted the U.S. attitude toward foreign participation, and thus, as suggested above, it is not unreasonable to expect that Japan and Korea will seek—and find—opportunities elsewhere. The consequences for the emerging U.S. industry, and the nation as a whole, could be enormous.

At the present time, in anticipation of serving these major world markets, the State of Alaska is aggressively pursuing development policies in the groundfish fishery off its shores, intended to induce rapid expansion of onshore processing capacity of groundfish. There are obvious short term and provincial reasons for Alaska to advocate this position. However, the evidence strongly suggests that onshore processing capacity, particularly in remote areas of Alaska which do not possess even the most rudimentary infrastructure needed to support this industry, may not be in the collective best interest of the nation, from an economic perspective.

Floating capacity, capable of self-contained mobile operation has a clear economic advantage in the high volume, relatively low unit value groundfish processing sector. And yet, significant political pressure, at virtually every level of decision making, and financial subsidies, both Federal and state, disproportionately favoring onshore facilities, have characterized the development of this industry in recent years. It has been suggested that these programs have induced the construction of facilities in locations of the state that cannot be sustained on an unsubsidized joint competitive basis. This has already resulted in the complication of fishery management allocation decisions in the Bering Sea groundfish fishery, owing to the shoreside facilities' reported inability to acquire raw material, i.e., groundfish, for processing at prices which make operation profitable, confronted as they are with competition from floating capacity.

To the extent that onshore processing development is artificially induced, whether through direct subsidy or political manipulation of the regulatory environment, the resulting expansion of U.S. utilization of the groundfish resources in the EEZ will be more costly than would be the case if alternative development strategies had been employed. In practice, the exercise has been instructive. It has generated new information on development and production costs, which will be invaluable in assessing, in retrospect, the merits of the Americanization policy to displace foreign fisheries and processors. But what if the markets, anticipated by the advocates of an accelerated Americanization of the U.S. EEZ, fail to materialize?

After all, even in the absence of the Americanization policy, Japanese and Korean interests may better be served by negotiating long-term contracts with other coastal countries that recognize the mutual benefits of such arrangements. The international Organization for Economic Cooperation and Development (OECD, 1986:137) has reported that, in addition to agreements with the United States and Morocco, "negotiations on fishery agreements . . . have been conducted by Japan with Canada, China, the Republic of Korea, Australia, New Zealand, and South Pacific countries. . . The main species sought are squid, bottomfish, etc." This understates Japanese participation in foreign fisheries including recent agreements in South America, among others, although some setbacks have reportedly been experienced, especially in U.S. waters, as cited above, and in Soviet waters.

Nonetheless, Japan continues to rely on its own fleets and processors to supply the domestic market,[3] although we do not know that these new arrangements are designed to substitute for Alaska pollock, in the large but declining Japanese surimi market. If they are, the consequences of the Americanization policy could be much different than expected.

Cooperative Research

It is precisely this environment of uncertainty that is, in our opinion, generating worldwide interest in cooperative research on international groundfish markets. With such dramatic changes in ownership of the ocean's living marine resources, there are new participants in these markets, especially new holders of resource wealth. As discussed above, this had led to some displacement of foreign fishing fleets and, hence, to interest in how to recoup apparent losses. Coastal countries with new EFJ zones, but in large part infant commercial groundfish sectors, seek ways to convert potential to realized gains. All of this is being contemplated in an environment of uncertainty about 1) the extent to which previously underutilized species may command economic attention, 2) the nature of the market for the many products of the groundfish fishery, and 3) the benefits and costs associated with cooperative fishing and processing arrangements.

One thing that has clearly emerged from this growing competition for access to, and control over, heretofore undesirable or uneconomic fisheries resources, is the image of a highly integrated and interdependent world market for seafood, particularly whitefish, commodities. In combination with declining availability of some important traditional groundfish products (including high valued Atlantic cod *Gadus morhua*, and haddock, *Melanogrammus aeglefinus*, fillets), lower valued block and minced block made from pollock, hakes, and any

[3]T.-N. Chen and D. L. Hueth. 1983. Welfare considerations in the development of a joint venture policy. *In* B. Melteff (editor), Proceedings of the International Seafood Trade Conference, 8–12 September 1982, Anchorage, Alaska, p. 461–471. Sea Grant Coll. Program, Univ. Alaska, Fairbanks, AK 99701.

number of other relatively abundant species, and growing worldwide demand for whitefish products (including fresh and frozen fillets, blocks, headed and gutted, and surimi), prospects for groundfish development appear bright, if as of now somewhat uncertain.

To aid in the resolution of some of this uncertainty regarding the anticipated growth in world whitefish production and trade, an international cooperative study of groundfish resource capabilities, trade flows, product forms, market characteristics, and demand was initiated in early 1987. The study, supported in part by the U.S. National Marine Fisheries Service, is intended to provide a comprehensive overview of the major worldwide groundfish resources. The study is designed in three phases. Phase one involves a global inventory of significant unutilized and underutilized groundfish species. This inventory will seek to identify 1) the species complex, 2) geographic distribution, 3) total size, 4) annual harvestable surplus, and 5) jurisdictional control, associated with significant populations which are perceived to have commercial potential.

Simultaneously, data on international seafood trade arrangements are being developed. These include 1) documentation of trade practices designed to establish and maintain markets, and 2) product flows in high-volume whitefish commodities. These could include indirect and direct subsidies, geopolitical arrangements, countertrading relationships, capital and/or technology transfers, etc. The purpose here is to establish a contextual framework for understanding existing seafood trade patterns and to assess the potential characteristics of future trading opportunities. Included in this portion of the phase-one analysis is a descriptive summary of the existing international joint venture arrangements, including their number, the participating partner nations, species complex targeted, and their institutional configuration.

Subsequent phases of the study will draw upon the data compiled in phase one to 1) quantitatively evaluate supply and demand relationships for whitefish commodity groups in the world market, 2) assess the sensitivity of demand to variations in total world production, and 3) examine the influence of macroeconomic, political, and resource management policy on world groundfish trade patterns. Perhaps the research addresses the point of Hemmi (1982), referred to earlier, about the need for full information.

In view of the many uncertainties surrounding the nature of supply and demand conditions for groundfish, it is not surprising that the response to the call for cooperative international research has been so resoundingly positive. Apparently the expected benefits from the insights generated are perceived to exceed costs of disclosing proprietary information.

Phase one of the study began in spring 1987 and involved more than 40 scientists from 23 nations around the world. Preliminary results of this phase of the study were to be available by spring 1988, and, assuming continued funding support, phase two was to begin then.

Acknowledgments

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A Comparison of Two Stratification Schemes Used in Sampling Canadian Atlantic Cod, *Gadus morhua*

DOUGLAS CLAY

Introduction

Management of commercial fisheries depends upon accurate catch statistics and representative sampling—preferably of the "catch" by sea sampling but often confined to "landings" by port sampling. Beckett (1983), in his review of sampling standards in the Canadian northwest Atlantic, indicated the importance placed on this subject by the International Commission for the Northwest Atlantic Fisheries (ICNAF). ICNAF set minimum sampling guidelines as "one sample per 1,000 tonnes of fish caught for each division, quarter of year, and gear. As an approximate guideline, such samples should consist of 200 fish from the entire length range for length composition and one fish per centimeter length group for age composition" (Anonymous, 1974:70–71). The interpretation of the expression ". . .per centimeter length group. . ." is considered to be 1, 2, or 3 cm length groups depending on species (Hodder[1]).

ABSTRACT—Sampling is a key element in the assessment of any fish stock. It is often one of the most expensive activities of the management process; thus, improved efficiency can result in significant cost savings. In most cases a two-phase sampling strategy is employed. Two commonly used versions of such stratified random schemes were simulated using a test population based on Atlantic cod, Gadus morhua. *A 1 otolith per 1 cm length frequency currently used for many flatfish and some smaller gadoids and a 3 otolith per 3 cm length frequency currently used for many of the larger gadoids. No difference was detected in the age composition or mean length at age for either scheme; however, 10 percent fewer otoliths were collected in 1 for 1 sampling than 3 for 3. There was an improvement of between 30 and 60 percent in the coefficient of variation of the estimated catch numbers at age using the 1 for 1 compared with the 3 for 3 stratified sampling. For these reasons and other operational considerations, the 1 for 1 stratified random design of sampling appears to be superior.*

Commercial sampling by Canada's Department of Fisheries and Oceans (DFO) along Canada's Atlantic coast has traditionally been conducted as a two-phase stratified process for the estimation of age composition. The first sample is a random length frequency and the second sample is a stratified sub-sample of otoliths taken from this length frequency. This sampling scheme was meant to collect otoliths, for age determination, from all length ranges of fish. At the same time the expense involved in determining ages from these sampled fish was to be minimized. As age and length are correlated, the most efficient method of sampling the unknown variable age is by stratifying by the known variable length. In addition, as other biological data were also being collected, it was felt that stratified schemes were more appropriate than random sub-sampling, despite the fact that random sub-sampling may provide greater precision in age at length keys (Kimura, 1977).

Three groupings have been used for various demersal fish species. These are 1 for 1 (1 otolith randomly collected for each centimeter interval observed in the length frequency of the sample) applied to the American plaice, *Hippoglossoides platessoides*; redfish, *Sebastes* sp.; silver hake, *Merluccius* sp., and other small fishes; 2 for 2 applied to haddock, *Melanogrammus aeglefinus*, only; and 3 for 3 applied to Atlantic cod, *Gadus morhua*, white hake, *Urophycis tenuis*, and other long fishes (Anonymous, 1974:128). The length frequency is recorded in 1 cm intervals by the port sampler who then transcribes the frequency into appropriate intervals for each species. Part of the logic in determining length grouping was the total number of intervals that could be keypunched on an 80-column data card. This was considered acceptable as the larger fish are generally thought to grow faster and thus show less variation in age within a 3 cm interval than smaller fish.

Powles (1983) outlined the sampling programs proposed for the Gulf (of St. Lawrence) Region of the DFO. In his plan he tried to optimize the human and financial resources required to obtain the best coverage of the diverse fisheries of this region. He did not carry his proposals down to the detail of stratification schemes for the collection of aging materials from the length-frequency samples. The Gulf region has since attempted to standardize the sampling for all species of demersal and pelagic finfish. One means of doing this is to sample otoliths and record length frequency data with a 1 for 1 stratification scheme on research cruises and in commercial sampling. An immediate

[1]Hodder, V. 1986. Assistant Executive Secretary, North Atlantic Fisheries Organization, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada. Personal commun.

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advantage of this is the reduction in errors due to transcribing the length frequency data obtained from the port sampler and the research survey. The data can be keypunched as recorded (1 for 1) rather than being pooled into larger groupings and transcribed, with the accompanying loss of precision, before keypunching.

This study attempts to identify what differences, if any, may arise from the different sampling stratification schemes. If there is no difference, then standardization of the length groupings for various demersal species could be considered.

Methods

During a survey on the research vessel *E. E. Prince* in September 1978, a total of 1,497 otolith pairs were collected from Atlantic cod. These observations of length and age were taken as the starting population from which simulated samples were drawn. The otoliths from this cruise were collected using a 3 for 3 stratification scheme and so are not to be taken as representing the "true" cod population in the southern Gulf of St. Lawrence in 1978. They are only a convenient sample starting "population" of lengths and ages upon which to simulate the effects of the two stratification schemes. To test the effect of sampling from small vs. large "populations" and to remove the necessity of applying the finite population correction (Cochran, 1977), a second data set comprising 10,186 observations was also used. These data were collected using the same sampling protocols from six research surveys conducted in September of each year between 1975 and 1981. Some confounding may occur in such a comparison as the larger multiyear data set will have additional variation caused by year-to-year population and growth differences.

From these samples of Atlantic cod ages and lengths, arranged in order of capture, random sub-samples of 200 fish were taken (with replacement for the small data set; without replacement for the large data set). In all simulated samples some data were lost as either no length was recorded or the otoliths were unreadable. Thus only 95–99 percent of possible fish were actually included in the sample.

The sample length frequency was made up of all fish with valid length data. The observations with valid ages were selected for catch at age calculations in two ways: 1) A 1 for 1 and 2) a 3 for 3 stratification scheme.

Data were randomly selected from the starting population and used to construct the length frequency. Two tests were then applied to the data to determine in which age-at-length key(s), if any, the data would be used. If no other fish of that cm length had been sampled, the corresponding age of the sampled fish was entered into the age length key for 1 for 1 sampling. If 2 or fewer fish had been sampled in the particular 3 cm length span in which the fish occurred, the age was entered into the age length key for 3 for 3 sampling. After 3 entries were made in a particular 3 cm length interval, no further age data were recorded in that interval. Thus a fish with valid data would end up recorded in the length frequency and in one, two, or none of the age length keys.

Two estimates of catch at age were calculated by individually applying the 1 cm age-at-length key and the 3 cm key to the length frequency, in the latter case, to a length frequency aggregated to 3 cm intervals.

The two-tailed Kolmogorov-Smirnov (K-S) test (Meddis, 1975) was used to test the null hypothesis that the sub-samples came from the same overall population and have the same distribution characteristics. The percentage age composition and the mean length at age were the parameters tested for the above hypothesis. This was based on the assumption that mean lengths represent the cumulative growth by length over the first 10 years of life and that there should be no differences in the age composition from the two sampling schemes. The above test was run using a microcomputer statistical package[2] (NWA, 1984).

[2]North West Analytical STATPAK, Portland, Oreg. Mention of trade names or commercial products does not imply endorsement by DFO, Canada, or the National Marine Fisheries Service, NOAA.

Table 1.—Sampling statistics for 1, 5, and 20 samples collected using a 1 for 1 (1:1) and a 3 for 3 (3:3) stratification scheme. Each sample consisted of 200 randomly selected Atlantic cod from a test population consisting of 1,497.

Item	Trials					Mean
No. of samples	1	1	1	1	1	1
No. of fish sampled	196	195	197	198	195	196
No. of otoliths (1:1)	55	54	51	51	53	53
No. of otoliths (3:3)	59	57	58	56	59	58
No. of samples	5	5				5
No. of fish sampled	993	994				994
No. of otoliths (1:1)	271	263				267
No. of otoliths (3:3)	292	301				297
No. of samples	20	20				20
No. of fish sampled	3,926	3,946				3,936
No. of otoliths (1:1)	1,108	1,062				1,085
No. of otoliths (3:3)	1,224	1,198				1,211

A comparison of the variance in mean length at age (Snedecor and Cochran, 1978) and in the variance in catch at age (Gavaris and Gavaris, 1983) was made between the two sampling schemes.

Several different simulations were conducted on both sample data sets using different random seeds for selecting (sampling) the fish. Generally only one of each of these simulations has been presented in this paper. However, despite slight differences observed from each of these runs, no change in conclusions would result.

Results

Age-length keys were developed from otoliths collected from individual samples (about 200 fish), 5 samples combined (about 1,000 fish), and 20 samples combined (about 4,000 fish). For 5, 2, and 2 trials respectively (Table 1), the number of otoliths collected by 1 for 1 sampling was from 9.5 to 11.5 percent less than with 3 for 3 sampling. During additional simulations one extreme observation of only a 5 percent difference was observed.

The mean length at age (Table 2a) estimated from two keys constructed from 20 samples of about 200 fish each show little difference between the stratification schemes (Fig. 1). Freidman's method (Sokal and Rohlf, 1981) gives chi squared values for this data in the range of 0.9–3.6 ($X_{(0.025,1)}$ = 5.02); this indicates the CV for the mean length at age was not signifi-

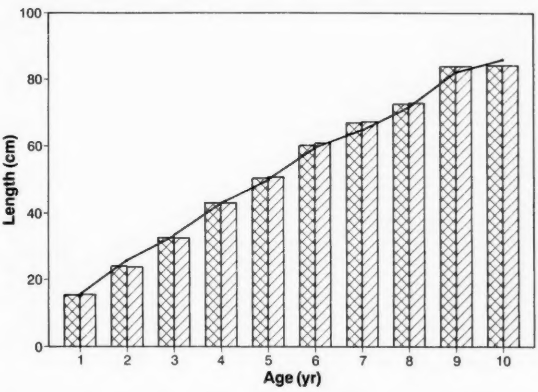

Figure 1.—Mean length at age estimated from the two sampling schemes based on 20 samples for each age at length key. Cross hatching is 1 for 1 sampling and single hatching is 3 for 3 sampling; the solid line represents the test population of Atlantic cod (1,497) from which the samples were taken.

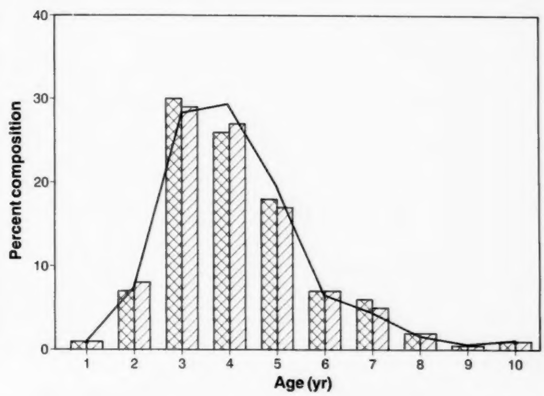

Figure 2.—Age composition estimated from the two sampling schemes based on 20 samples for each age at length key. Cross hatching is 1 for 1 sampling and single hatching is 3 for 3 sampling. The solid line represents the test population of Atlantic cod (1,497) from which the samples were taken.

Table 2a.—Mean length (cm) at age from a test population (1,497) as estimated from 1 for 1 (1:1) and 3 for 3 (3:3) sampling stratification schemes; 1, 5, or 20 samples were taken for the variuos trials.

		Ages									
		1	2	3	4	5	6	7	8	9	10
	Pop. mean length	16.0	27.0	33.4	42.3	50.2	59.6	63.1	69.6	80.2	87.0
No. sam.	Strat. scheme										
1	1:1	16.0	22.9	33.2	44.7	52.0	63.0	68.0	77.7	79.5	87.5
1	3:3	16.0	24.4	34.0	45.0	53.1	62.8	72.3	76.0	79.5	87.5
1	1:1	15.0	21.9	32.5	45.7	49.1	57.6	73.3	73.5	79.0	90.5
1	3:3	15.2	22.2	33.4	44.9	55.5	58.0	72.5	68.0	79.0	90.5
1	1:1	16.0	24.0	34.1	43.6	50.1	58.3	70.8	76.7		87.5
1	3:3	16.0	23.3	33.8	42.4	51.9	58.8	67.4	77.5		87.5
5	1:1	16.1	23.6	33.0	42.6	52.9	61.8	65.4	68.5	71.6	78.2
5	3:3	16.3	24.3	32.8	43.3	53.4	61.4	65.8	72.8	72.0	78.2
5	1:1	16.7	23.2	33.3	44.1	51.7	60.5	65.9	70.9		90.3
5	3:3	16.3	23.7	32.8	42.5	52.3	61.4	65.9	72.2		90.3
20	1:1	15.5	24.1	32.7	43.1	50.4	60.3	67.1	72.6	84.0	84.3
20	3:3	15.6	23.8	32.6	43.1	50.8	61.0	67.4	72.9	84.0	84.3
20	1:1	17.5	24.2	33.0	42.9	53.1	61.3	68.6	72.0		91.3
20	3:3	17.5	24.7	33.0	42.7	52.0	61.3	67.9	72.5		91.3

Table 2b.—Coefficients of variation of the mean length (cm) at age in the trials in Table 2a.

		Ages									
		1	2	3	4	5	6	7	8	9	10
	Pop. mean length	16.0	27.0	33.4	42.3	50.2	59.6	63.1	69.6	80.2	87.0
No. sam.	Strat. scheme										
1	1:1	12	13	13	8	8	7	7	7	9	8
1	3:3	12	13	14	8	8	8	8	7	9	8
1	1:1	7	13	12	9	14	5	4	14	8	7
1	3:3	7	14	12	9	12	5	4	16	8	7
1	1:1	10	14	13	9	10	8	8	10		8
1	3:3	10	13	13	9	11	8	7	10		8
5	1:1	13	13	13	9	10	8	9	8	7	7
5	3:3	13	13	12	10	11	9	10	9	8	7
5	1:1	10	14	13	11	10	8	10	10		10
5	3:3	10	14	13	11	10	9	12	10		9
20	1:1	16	16	12	10	10	10	10	10	10	8
20	3:3	16	16	12	10	10	10	9	10	10	8
20	1:1	11	14	12	11	10	9	10	9		9
20	3:3	10	14	12	10	11	9	11	9		9

cantly different between sampling schemes (Table 2b). They ranged from 7–18 percent over the sampled ages; the lowest values of 7–10 percent occurred in the ages contributing most to the population (4–8 years), and the remaining ages had CV's of their mean lengths between 10 and 18 percent.

The percentage age composition (Table 3) from these same two age length keys also shows little variation from the starting population (Fig. 2). There is no significant difference (K-S test) at the 5 percent level for any of the various levels of sampling intensity (i.e., 1–20 samples per key) for the percentage age composition or the mean length at age collected by the two sampling strategies (Table 4).

At the same time this study was underway, the sampling unit of our

Table 3.—Percent age composition of a test population (1,497) of Atlantic cod as estimated from 1 for 1 and 3 for 3 sampling stratification schemes; 1, 5, or 20 samples were taken for the various trials.

		Ages									
		1	2	3	4	5	6	7	8	9	10
	Population	.014	.075	.277	.292	.192	.068	.042	.016	.005	.008
No. sam.	Strat. scheme										
1	1:1	.01	.08	.36	.28	.18	.03	.03	.02	.01	.01
1	3:3	.01	.17	.29	.26	.17	.03	.02	.02	.01	.01
1	1:1	.04	.07	.38	.28	.15	.03	.02	.02	.01	.02
1	3:3	.03	.07	.38	.33	.09	.03	.02	.02	.01	.01
1	1:1	.01	.11	.37	.23	.16	.03	.05	.02	.00	.01
1	3:3	.01	.09	.32	.30	.13	.04	.08	.01	.00	.01
5	1:1	.02	.09	.29	.29	.19	.06	.04	.02	.01	.01
5	3:3	.03	.09	.31	.26	.18	.07	.03	.01	.00	.01
5	1:1	.02	.09	.34	.23	.18	.09	.02	.02	.00	.00
5	3:3	.02	.10	.30	.24	.20	.08	.02	.02	.00	.00
20	1:1	.01	.07	.30	.26	.18	.07	.06	.02	.00	.01
20	3:3	.01	.08	.29	.27	.17	.07	.05	.02	.00	.01
20	1:1	.01	.07	.28	.29	.20	.04	.06	.03	.00	.02
20	3:3	.01	.09	.24	.30	.20	.05	.06	.02	.00	.02

Table 5a.—Catch at age (total) and variance estimated using the two stratification schemes; 1 for 1 (1:1) and 3 for 3 (3:3) sampling of two populations of Atlantic cod. Three independent runs are given for each of the two data sets.

			No. of samples				
Run no.	Strat. scheme	Variable	1	3	5	10	20
Small data set[1]							
1		Catch	194	590	983	1,968	3,925
	1:1	Variance	—[2]	410	2,286	3,327	8,015
	3:3	Variance	1,716	836	3,923	7,566	17,600
2		Catch	195	585	983	1,949	3,897
	1:1	Variance	—[2]	865	1,798	3,983	6,399
	3:3	Variance	2,182	1,114	4,409	7,494	12,029
3		Catch	195	589	998	1,970	3,900
	1:1	Variance	—[2]	1,230	1,609	3,763	7,670
	3:3	Variance	1,628	2,337	4,524	8,497	12,779
Large data set[3]							
1		Catch	196	591	975	1,963	3,890
	1:1	Variance	—[2]	933	2,105	3,536	7,157
		Catch	196	570	975	1,951	3,887
	1:1	Variance	—[2]	1,621	2,034	3,477	6,970
	3:3	Variance	1,434	2,380	3,743	7,090	13,992
3		Catch	197	591	973	1,965	3,887
	1:1	Variance	—[2]	1,395	1,546	3,477	7,102
	3:3	Variance	664	2,656	2,593	6,623	13,387

[1]Sampled world = 1,497 fish.
[2]Unestimable value as only one individual is sampled in each length stratum.
[3]Sampled would = 10,186 fish.

Table 4.—The K statistic for the Kolmogorov-Smirnov two-sample test. (n1 = n2 = 10, for the two samples; the 1 for 1 and 3 for 3 sampling schemes on a test population of 1,497 Atlantic cod.) This test compares percentage age composition and mean length at age as estimated from samples collected by the two stratification schemes.

Percentage age composition		
Number of samples	K	Significance levels
1	0.201	Not significant at 5%
1	0.134	Not significant at 5%
1	0.157	Not significant at 5%
5	0.067	Not significant at 5%
5	0.089	Not significant at 5%
20	0.022	Not significant at 5%
20	0.089	Not significant at 5%
Mean length at age		
Number of samples	K	Significance levels
1	0.170	Not significant at 5%
1	0.331	Not significant at 5%
1	0.119	Not significant at 5%
5	0.078	Not significant at 5%
5	0.048	Not significant at 5%
20	0.014	Not significant at 5%
20	0.045	Not significant at 5%

region conducted an empirical study to investigate this subject. Lambert[3] used the two sampling schemes during part of the 1984 sampling season to double-sample the NAFO Division 4T Atlantic cod stock. He observed no significant differences in either the mean age composition or the mean size at age estimated by the two schemes.

The estimates of the catch in numbers at age (Table 5a) calculated according to the method of Gavaris and Gavaris (1983) indicates decreasing coefficients of variation (CV) with increasing numbers of samples (Table 5b). The CV's ranged from 5–8 percent with the two stratification levels and three samples to 2.17–3.38 percent with 20 samples (Fig. 3). The two-tailed F-test indicates a significant difference in the variance in every case; with the shift from the 1 for 1 stratification to the 3 for 3, this resulted in an increase in the CV of between 30 and 60 percent.

Conclusions

It was proposed by the FAO Working Party on Tuna Length Measurements and Tabulation (Anonymous, 1981) that the length groupings for sampling stratification follow the geometric progression of 0.5, 1, 2, 4, 8 cm, etc., to allow data to be compared after being aggregated (i.e., sharing the same midpoints). The main reason for stratifying is the reduction of the number of relatively expensive

Table 5b.—Summary of table giving the coefficient of variation for each estimated catch at age.

		No. of samples				
Run no.	Strat. scheme	1	3	5	10	20
Small data set[1]						
1	1:1	—[2]	3.43	4.86	2.93	2.28
2	1:1	—[2]	5.03	4.31	3.24	2.05
3	1:1	—[2]	5.95	4.02	3.11	2.25
1	3:3	21.36	4.90	6.37	4.42	3.38
2	3:3	23.96	5.71	6.76	4.44	2.81
3	3:3	20.69	8.21	6.74	4.68	2.90
Large data set[3]						
1	1:1	—[2]	5.15	4.68	3.00	2.17
2	1:1	—[2]	6.99	4.58	3.01	2.15
3	1:1	—[2]	6.32	3.99	3.18	2.17
1	3:3	24.86	8.81	6.17	4.17	2.99
2	3:3	19.33	8.80	6.40	4.34	3.04
3	3:3	13.08	8.72	5.31	4.10	2.98

[1]Sampled world = 1,497 fish.
[2]Unestimable value as only one individual is sampled in each length stratum.
[3]Sampled world = 10,186 fish.

[3]Lambert, J. D. 1986. Sampling biologist, Maurice Lamontagne Institute, Department of Fisheries and Oceans, Mont-Joli, Quebec, Can. Personal commun.

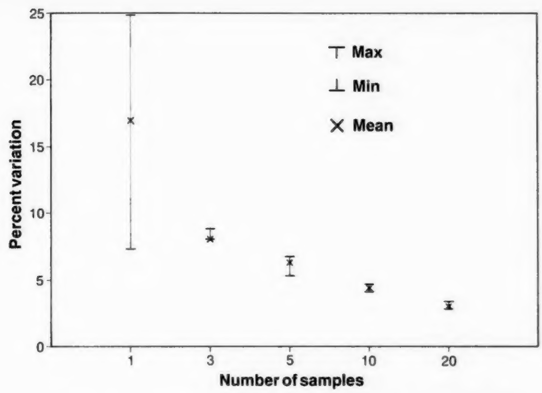

Figure 3.—Coefficient of variation (%) for the estimated catch in numbers at age for different numbers of samples. The range and mean CV's are shown for six independent simulations of the 3 for 3 sampling of a test population of Atlantic cod (10,186).

hard parts collected for aging while maintaining the representative nature of the sampling for the entire length range. Gulland (1955) suggested such sampling should aim to produce similar CV's for estimated numbers at age for all ages, and ICNAF (Anonymous, 1974:134) suggested a level of 10 percent would be satisfactory. Species should be selected for the stratified length groupings by their maximum range of length and the consideration of cost and the number of age determinations required. FAO (Anonymous, 1981) has suggested all fish with a maximum length less than 30 cm use the 0.5 cm grouping while fish over this use 1 cm.

In the test populations of Atlantic cod, there was no significant difference in the mean values of the data collected by the two sampling techniques. Although there was no advantage of one sampling scheme over the other with regard to the variance about the mean length, there is a distinct advantage in the 1 for 1 sampling scheme regarding the variance in the estimated catch numbers at age. The 1 for 1 stratification scheme would appear the superior one, as about 10 percent fewer otoliths are collected to provide the same or better information (depending on the parameter being estimated), thus reducing the costs of sampling and aging fish collected during both commercial sampling and research surveys. Further, the 1 for 1 stratification does not require transcribing of the data, resulting in fewer errors and less work.

The data presented here are for a simulated population of Atlantic cod collected from research surveys of the southern Gulf of St. Lawrence. The conclusions of this study cannot be categorically accepted for all species in both commercial and research situations; however, there is no reason to doubt that the conclusions would hold for the majority of gadoid species along the Atlantic coast. Commercial data tend to be similar to that collected from the same populations by research surveys except for varying degrees of truncation of the younger age groups.

One instance where this might not be considered a superior technique would occur if large numbers of otoliths were considered necessary for each age length key, such as in long-lived slow growing fish. If the fishery was considered adequately represented by the existing length frequencies, then excess length frequencies would be required so additional otoliths could be collected.

If statistical differences do not dictate a choice between the two stratification schemes, then other operational considerations will probably determine which of the schemes will be put in use. Four such considerations might be:

1 for 1	*>1 for >1*
1) Greater detail for biological analysis.	1) Not as sensitive to small changes in population parameters.
2) Fish with large length ranges will require forms that may be long and cumbersome.	2) Forms can be shorter and simpler although data requires summarizing and transcription.
3) If all species are sampled 1 for 1, then instructions can be simpler; samplers have one set of data forms for all species.	3) Variety of forms are required with different protocols for each sampling scheme.
4) Large volume of recorded data.	4) Data can be reduced to between 50 and 66 percent of the volume of the 1 for 1 scheme.

Jinn et al. (1987), in a study of optimal two-phase sampling, used examples that indicate the optimal sample size (for length measurements) could range from 150 to 250 fish for small (flatfish) and large (cod) fish, respectively. Baird (1983) developed a method to select the optimal number of otoliths to be collected at length for aging. In his study to achieve an overall CV of about 10 percent he had to vary the number of otoliths for different length strata. Thus it is probable that optimal efficiency in sampling may dictate a relatively complex scheme involving different numbers of fish:

1) Sampled for length (depending on the number of length strata involved for the species),

2) Stratified for otoliths (depending on growth rate of the stock), and

3) Possibly varying aggregations of lengths comprising the length strata.

Data can always be aggregated into larger groupings if it is collected in the smallest feasible intervals. Although

financial constraints may force stratification of detailed sampling, there is no justification for length frequency aggregation beyond 1 cm.

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Increasing Creel Interview Efficiency Through Early Survey Termination

HAL R. OSBURN and MIKE G. WEIXELMAN

Introduction

The Texas saltwater recreational sport-boat fishery is a biologically and economically important segment of the total Texas coastal fishery. Nearly 2.2 million fish were landed by Texas saltwater sport-boat anglers in 1984–85 (Osburn and Ferguson, 1986). Ferguson and Green (1987) estimated there were over 1.4 million saltwater fishing boat trips in Texas in 1982. Direct expenditures by these fishermen translated into over $1 billion of economic value annually to the State of Texas (Anonymous, 1985; Grubb, 1973).

The Texas Parks and Wildlife Department has monitored the sport-boat fishery in seven major bay systems of Texas since May 1974 using on-site creel interview methods (Osburn and Ferguson, 1986; Heffernan et al., 1976; Green et al., 1978). However, all boating activities were not monitored until September 1977 and all boat ramps with significant Gulf of Mexico (Gulf) fishing pressure were not monitored until May 1978. Since September 1979, all surveys at boat access sites have been conducted on both weekends and weekdays from 1000 to 1800 hours regardless of the amount of fishing activity. The efficiency of the monitoring program was improved in November 1984 by terminating weekend surveys at 1400 hours if no angler interviews had been conducted between 1000 and 1400 hours. Weixelman and Green (1984) found that this procedure would result in a coastwide loss of <4 percent of all angler interview and retained fish data. However, that study did not include weekday surveys, and areas fished (bay and Gulf) were not analyzed as separate effects. Fishing-trip characteristics of weekday anglers and Gulf anglers in Texas differ from those of weekend anglers and bay anglers, respectively (Osburn and Ferguson, 1986).

The purpose of this study was to evaluate the feasibility of terminating weekday surveys early and to re-evaluate weekend surveys using a larger data set. The objectives were to: 1) Determine if the percent of bay and of Gulf sport-boat angler interviews and retained fish missed in each season (high-use and low-use) was significantly different among termination times, day types (weekend and weekday), and bay systems; 2) estimate the percent of sport-boat angler interviews and retained fish that would be missed for each termination time by day type, season, area fished (bay and Gulf), and bay system; 3) determine if the number of survey days that could have been terminated early was significantly different among day types, seasons, and bay systems for each termination time; and 4) estimate the percent of days on which early termination can be expected to occur by termination time, day type, season, and bay system.

ABSTRACT—Operational modifications based on recreational angler activity patterns can be successfully formulated to increase creel survey efficiency without a significant loss of information. This study was conducted to estimate the amount of Texas marine sport-boat angler interview and retained fish data (bay and Gulf) that would be missed both coastwide and within each bay system if surveys were terminated early when no angler interviews were conducted by a specified time. Using this method, <3 percent of the total interviews and retained fish would be missed coastwide by terminating surveys at 1400 hours on weekends and 1600 hours on weekdays throughout the survey year. This would result in the early termination of 14 percent of the weekend surveys and 23 percent of the weekday surveys, thus allowing an annual redirection of 440 work-hours and $6,063 in operating expenses.

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Methods

Data for this study were collected from 15 May 1978 through 14 May 1985 (Osburn and Ferguson, 1986) on 4,397 randomly selected days on weekends and weekdays in the Galveston, Matagorda (including East Matagorda), San Antonio, Aransas, Corpus Christi, and upper and lower Laguna Madre bay systems. Each year consisted of a high-use season (15 May to 20 November) and a low-use season (21 November to 14 May). Methods used to survey sport-boat anglers (including private, party, and tournament) are described in Osburn and Ferguson (1986), Heffernan et al. (1976), and Green et al. (1978). Landings data were collected by interviewing sport-boat anglers as they completed a trip.

Sport-boat angler interviews conducted on each survey day were divided into 1-hour time periods (1000–1059, 1100–1159, 1200–1259, 1300–1359, 1400–1459, 1500–1559, 1600–

1659, and 1700–1800 hours) by day type, season, area fished, and bay system. On those days when no angler interviews were conducted from 1000 hours to each termination time (i.e., 1100, 1200, 1300, 1400, 1500, 1600 or 1700 hours), any interviews conducted after the termination times were assumed missed. The percents of interviews and retained fish that would have been missed had surveys been terminated early were calculated for each early termination time by dividing these missed data by all respective data collected. The percents were calculated for both areas fished on both day types during both seasons in each bay system (e.g., the number of Gulf angler interviews conducted after 1700 hours on weekends during the high-use season in the Galveston Bay system were divided by the total number of Gulf angler interviews conducted from 1000–1800 hours on weekends during the high-use season in the Galveston Bay system). The percents of missed information were also calculated on a coastwide basis because this corresponds to harvest estimation methodology used in presenting sport-boat landings in Osburn and Ferguson (1986).

Analyses of variance were conducted to determine if the mean percent of angler interviews missed and the mean percent of retained fish missed were significantly different among termination times, day types, and bay systems (Sokal and Rohlf, 1981). The effect of bay systems on the percent of missed information was examined to identify those areas where a coastwide application of an early termination time would cause the most bias in harvest estimates. There was no analyses of years because the purpose of this study was to evaluate the feasibility of terminating surveys early for all future years of the survey program and it was decided that analyzing the data with all years combined gave the most representative results that could be applied to future years. Analyses were performed for each season on bay angler interviews missed, bay retained fish missed, Gulf angler interviews missed, and Gulf retained fish missed. A posteriori testing of means was not possible since there were no replicate measures within cells. Analyses of variance were performed using arcsine transformed percents to assure a more normal distribution and equal variances. When differences among bay systems occurred, the data were visually examined and bay systems that appeared to be different were removed; the analysis of variance was then rerun. This procedure was repeated in a stepwise fashion until similar bay system groups were identified. Data from similar bay system groups were pooled and the percents of angler interviews and retained fish missed were recalculated (e.g., if there was no significant difference between percents of bay angler interviews missed during high-use weekend surveys in the Galveston and Matagorda Bay systems, then the high-use weekend data sets for these two bay systems were pooled and the percent of bay angler interviews missed was recalculated).

Survey days were placed into four categories based on the time interviews were conducted with respect to a proposed termination time. The categories were: 1) Days with all angler interviews from 1000 hours to a proposed termination time, 2) days with all angler interviews from a proposed termination time to 1800 hours, 3) days with angler interviews before and after the proposed termination time, and 4) days with no angler interviews. For each termination time, the number of days in each category was analyzed for significant differences among day types, seasons, and bay systems using a test of independence (Sokal and Rohlf, 1981). When differences among bay systems occurred the data were visually examined and bay systems that appeared to be different were removed; the test of independence was then reran. This procedure was repeated in a stepwise fashion until similar bay system groups were identified. The percent of days on which early termination can be expected to occur (2nd and 4th categories) was calculated by dividing the appropriately grouped data by the total number of survey days in the corresponding day type, season and bay system group.

Table 1.—Percent of angler interviews and retained fish that would have been missed coastwide by terminating a survey early when no angler interviews were conducted by a specified termination time by day type, season, and area fished.

		Weekend				Weekday			
		Bay		Gulf		Bay		Gulf	
Season	Termination time	Interviews	Fish	Interviews	Fish	Interviews	Fish	Interviews	Fish
High-use	1100h	18.0%	18.4%	16.8%	17.5%	43.9%	42.0%	40.2%	37.6%
	1200	4.4	4.5	4.5	5.9	15.1	14.9	13.9	16.4
	1300	1.3	1.1	1.7	4.2	5.9	5.6	4.8	6.6
	1400	0.4	0.3	0.4	1.9	3.3	2.9	3.0	4.9
	1500	0.2	0.2	0.2	0.8	1.6	1.1	1.8	3.1
	1600	0.1	0.1	0.1	0.7	0.7	0.5	0.9	1.9
	1700	<0.1	<0.1	<0.1	0.0	0.3	0.2	0.2	0.4
Low-use	1100	40.6	38.9	39.2	47.4	64.2	62.2	78.8	75.4
	1200	13.5	12.0	15.3	30.0	33.4	29.6	42.3	39.7
	1300	5.6	5.3	5.3	5.1	15.8	13.4	23.1	18.0
	1400	2.9	2.9	2.1	2.8	9.5	7.7	17.3	14.4
	1500	1.5	1.9	2.1	2.8	5.8	3.6	13.5	14.2
	1600	0.4	0.3	0.0	0.0	2.5	1.5	1.9	0.5
	1700	1.0	0.0	0.0	0.0	0.6	0.4	0.0	0.0

Results

Coastwide and for any season, <3 percent of bay and Gulf angler interviews and retained fish would be missed by terminating surveys at 1400 hours on weekends and at 1600 hours on weekdays (Table 1). The earlier the termination time, the greater the amount of missed information. For any given termination time, less information was missed on weekends compared with weekdays and during the high-use season compared with the low-use season. For any given termination time during the high-use season, the amounts of bay and Gulf angler information missed were sim-

ilar; however, during the low-use season, less information was normally missed on bay anglers.

The percent of angler interviews and retained fish that would be missed if surveys were terminated early (before 1800 hours) varied significantly (P <0.05) among day types, seasons, areas fished, and bay systems (Table 2), although some bay systems were similar ($P \geq 0.05$) and these bay systems were grouped accordingly (Tables 3 and 4). During the high-use season, the bay system groups that missed the most bay angler information varied by day type and type of information missed (interview vs. retained fish); however, for missed Gulf angler information, the Galveston Bay system was always the highest (Table 3). During the low-use season, the bay system groups that missed the most bay angler information varied by day type and type of information missed, except that both the Matagorda and Aransas Bay systems were always in those groups with only one exception each (Table 4). For missed Gulf angler information in the low-use season, all bay systems were similar.

Applying a coastwide termination time of 1400 hours on weekends and 1600 hours on weekdays, during the high-use season the greatest survey bias would occur in the Galveston Bay system where 6.6 percent and 7.9 percent of the Gulf retained fish would be missed on weekends and weekdays, respectively. During the low-use season, the Matagorda and Aransas Bay systems would be most out of line with the coastwide average loss of information; on weekends, 7.2 percent of the bay retained fish would be missed in both bay systems while on weekdays 5.1 percent of the bay angler interviews would be missed in the Matagorda Bay system.

Coastwide, 14 percent of all weekend surveys could be terminated at 1400 hours and 23 percent of all weekday surveys could be terminated at 1600 hours (Table 5). The earlier the termination time the greater the proportion of survey days that could be terminated early. For any given termination time, a greater proportion of surveys days could be terminated on weekdays compared with weekends

Table 2.—Summary of results of three-way analyses of variance of the percent of interviews and of retained fish missed by termination time, day type, and bay system for bay and for Gulf anglers in the high- and in the low-use season.

Group and season	Source of variation	Degrees of freedom	Sum of squares	F value	Group and season	Source of variation	Degrees of freedom	Sum of squares	F value
Bay inter-	Total	97	13,056.69		Gulf inter-	Total	55	7,701.36	
views	Time	6	10,602.44	632.54*	views	Time	6	5,266.21	161.68*
High-use	day type	1	1,412.72	505.70*	High-use	day type	1	737.95	135.94*
	Bay	6	256.58	15.31*		Bay	3	895.78	55.00*
	Time×Day type	6	499.31	29.79*		Time×Day type	6	316.14	9.71*
	Time×Bay	36	127.36	1.27NS		Time×Bay	18	326.09	3.34*
	Day type×Bay	6	57.71	3.44*		Day type×Bay	3	61.48	3.78*
	Error	36	100.57			Error	18	97.71	
Low-use	Total	97	24,372.24		Low-use	Total	55	26,198.33	
	Time	6	20,516.37	693.90*		Time	6	18,349.13	36.75*
	Day type	1	1,915.89	388.79*		Day type	1	1,295.67	15.57*
	Bay	6	562.53	19.03*		Bay	3	121.25	0.49NS
	Time×Day type	6	285.86	9.67*		Time×Day type	6	690.49	1.38NS
	Time×Bay	36	595.91	3.36*		Time×Bay	18	2,347.04	1.567NS
	Day type×Bay	6	318.28	10.77*		Day type×Bay	3	1,896.69	7.60*
	Error	36	177.40			Error	18	1,498.06	
Bay fish	Total	97	13,239.44		Gulf fish	Total	55	9,065.28	
High-use	Time	6	10,750.30	533.78*	High-use	Time	6	5,308.03	132.45*
	Day type	1	1,356.56	404.14*		Day type	1	664.30	99.46*
	Bay	6	305.71	15.18*		Bay	3	2,106.48	105.13*
	Time×Day type	6	473.50	23.51*		Time×Day type	6	214.15	5.34*
	Time×Bay	36	171.34	1.42NS		Time×Bay	18	614.91	5.11*
	Day type×Bay	6	61.19	3.04*		Day type×Bay	3	37.19	1.86NS
	Error	36	120.84			Error	18	120.22	
Low-use	Total	97	24,610.23		Low-use	Total	55	31,168.21	
	Time	6	20,676.43	286.78*		Time	6	21,962.20	25.36*
	Day type	1	1,310.80	109.08*		Day type	1	630.58	4.37NS
	Bay	6	710.30	9.85*		Bay	3	545.33	1.26NS
	Time×Day type	6	354.12	4.91*		Time×Day type	6	1,212.89	1.40
	Time×Bay	36	710.16	1.64NS		Time×Bay	18	3,418.89	1.32NS
	Day type×Bay	6	415.82	5.77*		Day type×Bay	3	800.75	1.85NS
	Error	36	432.60			Error	18	2,597.59	

* = Significant at $P<0.05$.
NS = Not significant at $P=0.5$.

Table 3.—Percent of high-use season angler interviews and retained fish that would have been missed by terminating a survey early when no angler interviews were conducted by a specified termination time by day type, area fished and bay system group[1]. (Number in parentheses is mean number of interviews or retained fish for respective survey period and area fished.)

	Weekend								Weekday								
	Bay				Gulf				Bay				Gulf				
	Interviews		Fish		Interviews		Fish		Interviews		Fish		Interviews		Fish		
Termination time	G-M-A (1,314)	S-C-U-L (2,091)	G-M (6,040)	S-A-C-U-L (15,667)	G (32)	M-S-A-C-U-L (545)	G (141)	M-S-A-C-U-L (2,886)	G-S-C-L (1,475)	M-A-U (972)	M (1,958)	G-S-A-C-U-L (17,072)	G (11)	M-S-A-C-U-L (242)	G (86)	M-S-A C-U-L (1,414)	L (203)
1100h	25.5%	13.5%	27.5%	14.1%	20.5%	16.4%	34.5%	15.1%	41.2%	49.6%	56.8%	40.8%	45.8%	39.8%	50.4%	38.3%	29.1%
1200	5.6	3.7	5.6	4.0	13.5	3.5	22.1	3.6	13.4	18.6	27.4	13.9	39.6	11.8	43.2	15.3	8.5
1300	2.2	0.7	2.1	0.6	10.9	0.7	20.6	1.9	4.7	8.5	11.0	5.2	25.0	3.2	33.7	5.0	0.6
1400	0.7	0.2	0.6	0.1	2.0	0.2	6.6	1.3	2.5	4.7	7.8	2.5	13.5	2.1	17.7	4.5	0.6
1500	0.4	0.1	0.5	0.1	1.3	0.1	6.3	0.0	1.1	2.5	1.8	1.0	10.4	1.1	15.3	2.4	0.0
1600	0.2	0.1	0.1	0.1	0.7	0.1	5.3	0.0	0.4	1.3	1.3	0.5	2.1	0.8	7.9	1.6	0.0
1700	0.1	0.1	0.1	0.0	0.3	0.0	0.0	0.0	0.2	0.7	1.1	0.1	1.0	0.1	0.0	0.5	0.0

[1]G = Galveston Bay system, M = Matagorda Bay system, S = San Antonio Bay system, A = Aransas Bay system, C = Corpus Christi Bay system.
U = upper Laguna Madra system, and L = lower Laguna Madre system.

Table 4.—Perent of low-use season angler interviews and retained fish that would have been missed by terminating a survey early when no angler interviews were conducted by a specified termination time by day type, area fished and bay system group[1]. (Number in parentheses is mean number of interviews or retained fish for respective survey period and area fished.)

	Weekend							Weekday							
	Bay					Gulf		Bay						Gulf	
	Interviews		Fish			Interviews	Fish	Interviews			Fish			Interviews	Fish
Termination time	G-M-A-L (387)	S-C-U (268)	G-U-L (983)	M-A (872)	S-C (535)	G-M-S-A-C-U-L (38)	G-M-S-A-C-U-L (975)	G-C-L (208)	M (63)	S-A-U (127)	G-C-L (1,885)	M (302)	S-A-U (747)	G-M-S-A-C-U-L (8)	G-M-S-A-C-U-L (155)
1100h	50.3	31.9	37.5	54.7	34.8	39.2	47.4	60.4	66.7	69.6	59.2	71.1	65.4	78.8	75.4
1200	18.7	8.9	14.0	22.8	4.6	15.3	30.0	29.2	47.2	36.7	24.6	48.5	34.4	42.3	39.7
1300	8.8	2.8	6.6	8.5	1.9	5.3	5.1	11.8	27.0	19.6	8.2	23.9	19.9	23.1	18.0
1400	3.8	2.0	3.1	7.2	0.8	2.1	2.8	6.3	18.6	12.4	4.6	22.2	10.0	17.3	14.4
1500	2.3	0.8	2.6	2.7	0.4	2.1	2.8	3.9	14.8	6.6	2.6	15.1	3.2	13.5	14.2
1600	0.4	0.3	0.1	0.8	0.4	0.0	0.0	1.6	5.1	3.3	1.0	3.2	2.1	1.9	0.5
1700	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.4	2.5	0.6	0.5	0.4	0.2	0.0	0.0

[1]G = Galveston Bay system, M = Matagorda Bay system, S = San Antonio Bay system, A = Aransas Bay system, C = Corpus Christi Bay system. U = upper Laguna Madra system, and L = lower Laguna Madre system.

Table 5.—The number and percent of survey days coastwide that could have terminated early when no angler interviews were conducted by a specified termination time by day type and season.

	Season					
Termination time	High-use		Low-use		Annual	
	No.	%	No.	%	No.	%
Weekend						
1100h	84	39.6	57	67.9	141	47.6
1200	40	18.9	37	44.0	77	26.0
1300	25	11.8	28	33.3	53	17.9
1400	18	8.5	23	27.4	41	13.9
1500	14	6.6	20	23.8	34	11.5
1600	11	5.2	17	20.2	28	9.5
1700	9	4.2	15	17.9	24	8.1
Weekday						
1100	300	67.9	140	83.3	440	72.1
1200	190	43.0	114	67.9	304	49.8
1300	133	30.1	94	56.0	227	37.2
1400	109	24.7	82	48.8	191	31.3
1500	89	20.1	72	42.9	161	26.4
1600	76	17.2	62	36.9	138	22.6
1700	66	14.9	54	32.1	120	19.7

Table 6.—Number and percent of survey days that could have terminated early when no angler interviews were conducted by a specified termination time by day type, season and bay system group.

Season and Day	Termination time	Bay system group	Survey days terminated early percent	Number
High-use Weekend	1100h	G-M-A	49.2%	46
		S-C-U-L	31.6	38
	1200	G-M-A	25.0	23
		S-C-U-L	13.9	17
	1300	G	21.4	7
		M-S-A-C-U-L	9.9	18
	1400	G-M-S-A-C-L	9.2	17
		U	2.4	1
	1500	G-M-S-A-C-L	7.2	13
		U	2.4	1
	1600	G-M-S-A-C-U-L	5.2	11
	1700	G-M-S-A-C-U-L	4.2	9
Weekday	1100	G-M-A-C-U	71.6	236
		S	55.7	26
		L	57.8	38
	1200	G-M-A-U	48.9	129
		S-L	31.6	35
		C	38.8	26
	1300	G-S-C	31.4	56
		M-A-U	34.3	68
		L	13.4	9
	1400	G-M-A-C-U	28.2	93
		S	20.7	10
		L	9.1	6
	1500	G-M-A-C-U	23.3	77
		S-L	11.1	12
	1600	G-M-A-U	20.5	54
		S-C	15.9	18
		L	5.4	4
Weekday (cont.)	1700	G-M-A-U	18.0	48
		S-C	13.8	15
		L	5.1	3
Low-use Weekend	1100	G-M-A	81.1	29
		S-C-U-L	58.3	28
	1200	G-M-A	56.4	20
		S-C-U-L	35.3	17
	1300	G-M-A	43.6	16
		S-C-U-L	24.2	12
	1400	G-M-A	37.9	14
		S-C-U-L	19.2	9
	1500	G-M-A	32.9	12
		S-C-U-L	16.3	8
	1600	G-M-A	29.3	11
		S-C-U-L	13.4	6
	1700	G-M-A-U	22.0	11
		S-C-L	12.2	4
Weekday	1100	G-M-S-A-C-U-L	83.6	140
	1200	G-S-A-C-U-L	65.1	94
		M	83.0	20
	1300	G-S-A-C-U-L	53.8	77
		M	71.0	17
	1400	G-M-S-A-C-U-L	48.8	82
	1500	G-M-S-A-C-U-L	42.7	72
	1600	G-M-S-A-C-U	38.8	56
		L	24.0	6
	1700	G-M-S-A-C-U-L	32.1	54

[1]G = Galveston Bay system, M = Matagorda Bay system, S = San Antonio Bay system, A = Aransas Bay system, C = Corpus Christi Bay system, U = upper Laguna Madre system, and L = lower Laguna Madre system.

and during the low-use season compared with the high-use season.

The proportion of survey days that could be terminated early varied significantly ($P < 0.05$) among day types, seasons,and bay systems, although some bay systems were similar ($P \geq 0.05$) and these bay systems were grouped accordingly (Table 6). For each termination time, the bay system groups varied by day type and season; however, the Galveston, Matagorda, and Aransas Bay systems were nearly always in the groups with the highest percent of potential early termination days. Applying a coastwide termination time of 1400 hours on weekends and 1600 hours on weekdays, these three bay systems would realize the greatest proportion of early terminated surveys with 9 percent and 30 percent, respectively, during the high-use season and 38 percent and 39 percent, respectively, during the low-use season. The lower Laguna Madre system was nearly always in the group with the least proportion of early terminated surveys.

Discussion

On-site creel surveys are used to estimate values, such as fishing pressure and landings, needed to assess fisheries and to formulate management strategies (Malvestuto, 1983). A basic disadvantage of this survey method, however, is that time spent surveying at low activity sites is not cost effi-

cient. Simply limiting the number of creel survey samples to lower costs could result in the precision of estimates being reduced (Best and Boles, 1956). Weixelman and Green (1984), however, found that weekend surveys of bay anglers could be terminated at 1400 hours when no angler interviews had been conducted and <4 percent of coastwide angler interview and retained fish data would be missed. This study confirmed those results for Gulf anglers and demonstrated that weekday surveys of both bay and Gulf anglers can also be terminated early when no angler interviews have been conducted by a specified time with a minimal loss of survey information.

According to Weixelman and Green (1984) the advantages of terminating unproductive creel surveys early are threefold: 1) More effective use of personnel time, 2) improved personnel morale, and 3) improved public relations. The disadvantage is missed information. In each creel survey program, the administrative agency must determine how much information can be missed and still maintain the statistical credibility of the study. For the current Texas Parks and Wildlife Department saltwater sport boat fishery monitoring program, a <3 percent loss of coastwide survey information would result in reductions in estimates of annual total finfish landings of approximately 2 percent (Osburn and Ferguson, 1986; TPWD[1]).

Assuming the tolerable loss of coastwide information for either bay or Gulf anglers is <5 percent for any day type and season, then maximum efficiency would result from early termination times of 1300 hours on weekends and 1400 hours on weekdays in the high-use season and 1400 hours on weekends and 1600 hours on weekdays in the low-use season. Consideration must be given, however, to the uniformity and ease of applying early termination procedures as well as to the effect on individual bay system estimates. We recommend that early termination times of 1400 on weekends and 1600 on weekdays be adopted coastwide throughout the survey year. This would allow an average of 179 surveys annually to be terminated early, thus resulting in the redirection of 440 survey personnel manhours and $6,063 in operating expenses, including $5,413 in salaries and $650 in meal reimbursements.

Acknowledgments

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[1]TPWD Marine Laboratory, Rockport, Tex. Unpubl. data

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The Driftnet Fishery in the Fort Pierce-Port Salerno Area off Southeast Florida

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Introduction

A commercial driftnet fishery for king mackerel, *Scomberomorus cavalla*, in the Fort Pierce-Port Salerno area off the east coast of Florida expanded from 1985 through 1987. The use of driftnets (gillnets that are not anchored) in the king mackerel fishery has concerned traditional handline trollers, as well as recreational and conservation groups. To gain a better understanding of this fishery and to provide the South Atlantic and Gulf of Mexico Fishery Management Councils with information to manage the king mackerel fishery, observations on the driftnet fishery were made by the National Marine Fisheries Service (NMFS) from May through September 1987.

ABSTRACT—From May through September 1987, observations were made on 38 trips in the driftnet fishery off the Fort Pierce-Port Salerno area off southeast Florida. Of the number and weight of fish landed on observed trips, 91.6 percent consisted of king mackerel, Scomberomorus cavalla, *the targeted species. Over 33 species of fishes were observed among the discarded by-catch. The most frequently occurring species in the discards was little tunny,* Euthynnus alletteratus, *which made up 67.0 percent by number of the discarded by-catch. Total landings for all commercial gear from Saint Lucie and Martin counties (the counties of the study area) increased 516,741 pounds from 1986 to 1987. In 1986, 55 percent of the catch was from handline and 45 percent from driftnet landings. In 1987, 78 percent was from driftnet and 22 percent from handline landings. A comparison of lengths from recreational and commercial landings showed recreationally caught fish to be, on the average, smaller. No marine mammals, birds, or turtles were entangled in the net on observed trips. Data on cost of nets, fuel, and supplies plus the distribution of earnings among the crew were obtained for five driftnet boats.*

Trips were made during the 5 days before and after the new moon of each month. Every boat captain that was contacted agreed to carry an observer, and during the course of the study, trips were made at least once aboard each of the boats that fished driftnets full time in the area. Thirty-eight observer trips were made. These represented 5.2 percent of the total recorded trips (731) made by driftnetters in 1987. In addition to observations at sea, dock interviews were conducted; information collected during dock interviews was consistent with that collected by shipboard observers. There was no indication that observed trips fished in different areas or in a different manner than unobserved trips. Cooperation of fishermen with observers was excellent throughout the study.

Description of the Fishery

History

The use of power-assisted encircling (run-around) gillnets and spotter planes for king mackerel started in the Naples, Florida area around 1963 (Beaumariage, 1973). The traditional method of commercial fishing for king mackerel in the study area has been handline (trolling), which dates back to at least the turn of the century (Austin et al., 1978). The use of run-around gillnets spread to the Florida Keys in the early 1970's and was later adapted to the Fort Pierce-Port Salerno area in the late 1970's. Boats using this gear had average landings of 8,000-10,000 pounds per successful trip with catches as high as 30,000-35,000 pounds (Austin et al., 1978). Several purse-seine boats fished for king mackerel and Spanish mackerel, *S. maculatus*, from 1983 to 1986 in the study area. The highest catch of king mackerel at that time was 56,650 pounds (Fable and Nakamura, 1986).

Both purse seines and run-around gillnets are only feasible when fish are tightly schooled, which normally happens only in January, February, and March in the study area. Environmental conditions may prolong this condition into April, as was the case in 1988, when successful purse seine and run-around gillnet sets were made.

While the use of king mackerel driftnets by a few small boats can be traced back to at least the early 1960's on a very limited and seasonal basis in the study area, their use by larger power-assisted gillnet boats (hi-rollers) did not start until the early 1980's. Nets used in 1980–81 were made of lighter webbing (#6) and were not as deep (120 meshes) as those used at present. Only a few boats were involved and landings were inconsistent. At least one of the nets used then was 3,000 yards long. Fishermen reported a few good trips, up to 7,700 pounds on one occasion, but had con-

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Table 1.—King mackerel driftnet boats that fished during the 1987 season off the Fort Pierce-Port Salerno area of Florida showing length of boat (feet), length of nets (yards) at start and at end of the season, participation, pounds of king mackerel (KM) landed, number of trips, and home port.

Boat	Boat length	Net length Start	Net length End	When fished	KM catch	No. trips	Home port
A	40	2,800	4,500	Apr.-Sept.	124,449	80	Port Salerno
B	50	4,000	5,500	Apr.-Sept.	121,064	68	Fort Pierce
C	48	2,800	4,500	Apr.-Sept.	118,029	85	Port Salerno
D	50	2,700	3,700	Apr.-Sept.	98,108	77	Fort Salerno
E	48	3,000	3,000	Apr.-Sept.	79,783	77	Fort Pierce
F	46	2,700	3,000	Apr.-Sept.	79,231	83	Fort Pierce
G	34	2,300	3,000	Apr.-Sept.	47,628	79	Port Salerno
H	47	2,400	2,800	June-Sept.	43,441	64	Fort Pierce
I	48	Unknown		Apr.-Sept.	32,024	39	Fort Pierce
J	30	2,000	2,000	Aug.-Sept.	6,899	18	Fort Pierce
K	37	1,500	1,500	July-Aug.	6,831	20	Port Salerno
L	50	Unknown		Sept.	10,249	25	Fort Pierce
M	32	1,000	1,000	May-Sept.	3,330	16	Port Salerno
Totals					771,066	731	

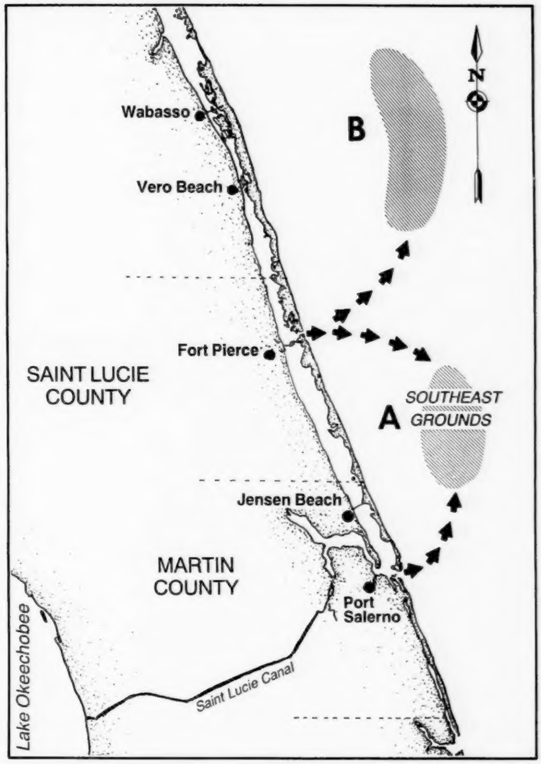

Figure 1.—The fishing grounds in the Fort Pierce (Saint Lucie County)-Port Salerno (Martin County) area of southeast Florida. A = southeast grounds and B = unnamed grounds to the northeast of Fort Pierce.

tinual mending problems, which they blamed on sharks passing through the net.

From 1980 to 1984 king mackerel driftnet effort did not increase substantially. The number of boats, the number of trips, and total landings per year were lower than in the last several years.

In the summer of 1985, a renewed interest in driftnetting by a few Port Salerno gillnet boats occurred. Landings remained inconsistent, but fishermen became more proficient in using the gear. They fished heavily around the new moon, when the nights were the darkest. They also learned to stay away from areas where sharks were concentrated and the water was too deep for effective fishing.

In 1986 the number of driftnet boats increased to seven. Fishermen were using new and stronger nets, which they dipped in black net coating that helped to strengthen the net, as well as decrease visibility to fish. The average length of net was 2,500-3,000 yards. Boats fished on a regular basis from April through September. Catch rates improved and fishermen reported less problems with sharks, possibly due to a developing shark fishery in the same area.

In 1987 the number of king mackerel driftnet boats increased to 13, eight of which fished full time (Table 1). The average length of net increased to ≥3,000 yards. Fishermen realized a direct relationship between length of net and catch.

Net length, labor, and boat space are the main limiting factors to the amount of net that can be feasibly set by one boat. At least one boat, on occasion, has reportedly set as much as 7,000 yards of net. This fishery has yet to draw any boats from outside the study area.

Fishing Area

During the 1987 season, the Port Salerno boats fished in the Southeast Grounds (A, Fig. 1), centered between Saint Lucie and Fort Pierce Inlets off Jensen Beach. The Fort Pierce boats fished this same area, as well as the unnamed grounds to the northeast of Fort Pierce Inlet (B, Fig. 1). Boats must set their nets 3 miles offshore in the Exclusive Economic Zone, since driftnetting for king mackerel is prohibited in Florida waters. Driftnet sets are usually made in 45-65 feet of water over sand bottoms with no noticeable obstructions to hang up the net. Fishermen avoid fishing directly offshore of inlets because of higher boat traffic, and because these areas often have high concentrations of sharks.

Vessels

In 1987, the period covered by this report, 13 vessels were engaged in the driftnet fishery in the Fort Pierce-Port Salerno area. This number includes five boats that did not fish full time for

Figure 2.—A typical driftnet boat operating in the Fort Pierce-Port Salerno, Fla., area.

the entire season. Present boats are standard fiberglass run-around gillnet boats (Fig. 2) ranging from 30 to 50 feet in length (Table 1). While driftnetting, each boat is operated by a captain and a crew of two or three. The captain is not necessarily the owner of the boat.

The same vessels in the driftnet fishery normally set run-around gillnets for Spanish mackerel or bluefish, *Pomatomus saltatrix*, from November to March. Some also set larger mesh driftnets for sharks from October through April before and after the Spanish mackerel season. Winter has traditionally been the prime fishing time for these boats. Driftnetting from April to September has helped to fill a void when large net boats used to remain idle. Fishermen have become more dependent on summer driftnet landings for a substantial portion of their income.

Gear

Present driftnets are constructed of #9-nylon 5-inch stretched-mesh webbing that is white when purchased. Webbing is purchased by the pound, with 2,000 pounds of webbing equal to 3,000 yards. Before use, the net is dip-coated in black net coating to increase strength and decrease visibility. All new netting purchased since 1986 is 140 or 150 meshes deep (about 50 feet). Floats are placed about every yard on the top of the net, and the bottom is weighted by a lead core line weighing 85 pounds/200 yards. Buoys equipped with battery-operated strobe lights are secured at both ends of the net. The buoy may or may not include a radar reflector.

Fishing Patterns

The normal driftnet season has been from mid-April through September. Winter driftnetting for king mackerel has been tried on occasion, but with little success. Presently it is not considered feasible because: 1) The same boats are involved in the Spanish mackerel and bluefish run-around gillnet fishery or shark driftnet fishery and 2) large schools of sharks, tarpon, *Megalops atlanticus*; and bluefish are present in the area and are a potential hazard to the net.

All king mackerel driftnetting takes place at night. The amount of moonlight is considered to have a direct effect on catch rates. Fishermen normally do not fish for about 3-4 days before and after the full moon, because the best fishing is considered to occur on the darkest nights (new moon). Net pickup usually starts before dawn, because king mackerel catches decrease and by-catches increase with daylight. Current is another factor considered to have an effect on catch rates. A strong southward current is considered detrimental, and some boats do not fish when such conditions prevail. Fishermen state that bioluminescence in the water is increased by strong currents pushing water through the nets, thus making the nets more visible.

Fishing Procedures

On a normal fishing day, driftnet boats leave port late in the afternoon and return with their catch the following day. Once the boat has reached its chosen destination and is ready to set the net, a strobe-light buoy is fastened to the free end of the net and dropped overboard. The boat then moves in a straight line away from the trailing net and buoy. The boat continues forward until the entire net has been pulled over the stern. Another buoy is then attached to the other end. The net is generally set running east and west, perpendicular to the coast. The net is never deployed before sunset. Optimally, the net remains in a straight line perpendicular to shore for the entire drift, but wind and current may cause it to curve or fold, thus reducing the effective fishing length. When a strong current is running, the nets will sometimes be set at an angle to the shore.

After the net has been set, the boat may decide to: 1) Tie onto one end of the net, 2) drift along with the net but not tie to it, or 3) anchor the boat and let the net drift. This decision is based on weather and current conditions. Driftnet boats are normally in radio contact with each other while setting their nets to assure that there is enough space separating each net to keep them

Table 2.—Discarded by-catch of the drift gillnet boats carrying NMFS observers off Fort Pierce-Port Salerno, Fl., from May through September 1987. Numbers are based on 38 trips.

Species	Number caught	% of by-catch	% of total catch[1]
Little tunny, *Euthynnus alletteratus*	1,854	67.0	23.1
Barracuda, *Sphyraena* sp.	300	10.8	3.7
Atlantic moonfish, *Selene setapinnis*	100	3.6	1.2
Smooth dogfish, *Mustelus canis*	95	3.4	1.2
Sharks, var. spp.	89	3.2	1.1
Filefish, *Aluterus* sp.	73	2.6	0.9
Lookdown, *Selene vomer*	53	1.9	0.7
Remora, *Remora remora*	32	1.2	0.4
Cownose ray, *Rhinoptera bonasus*	27	1.0	0.3
Sailfish, *Istiophorus platypterus*	22	0.8	0.3
Blue runner, *Caranx crysos*	21	0.8	0.3
Hammerhead shark, *Sphyrna* sp.	16	0.6	0.2
Atlantic croaker, *Micropogonias undulatus*	15	0.5	0.2
Crevalle jack, *Caranx hippos*	12	0.4	0.1
Atlantic thread herring, *Opisthonema oglinum*	10	0.4	0.1
Atlantic bumper, *Chloroscombrus chrysurus*	8	0.3	0.1
African pompano, *Alectis ciliaris*	8	0.3	0.1
Greater amberjack, *Seriola dumerili*	6	0.2	0.1
Flounders, var. spp.	5	0.2	0.1
Scorpionfishes, var. spp.	3	0.1	<0.1
Triggerfishes, var. spp.	2	0.1	<0.1
Striped searobin, *Prionotus evolans*	2	0.1	<0.1
Atlantic manta, *Manta birostris*	2	0.1	<0.1
Black snapper, *Apsilus dentatus*	2	0.1	<0.1
Tiger shark, *Galeocerdo cuvieri*	1	<0.1	<0.1
Stingray, Dasyatidae	1	<0.1	<0.1
Permit, *Trachinotus falcatus*	1	<0.1	<0.1
Gag, *Mycteroperca microlepis*	1	<0.1	<0.1
Atlantic guitarfish, *Rhinobatos lentiginosus*	1	<0.1	<0.1
Blacktip shark, *Carcharhinus limbatus*	1	<0.1	<0.1
Cowfish, *Lactophrys* sp.	1	<0.1	<0.1
Butterfish, *Peprilus triacanthus*	1	<0.1	<0.1
Atlantic bonito, *Sarda sarda*	1	<0.1	<0.1

[1]Total catch = number of landed and discarded fishes of all species.

from getting entangled. Six or seven boats may fish in the same immediate area. All driftnet boats are equipped with Loran C and use this to aid in setting and tracking the net.

Total soak time varies with each trip, but rarely exceeds 12 hours. The maximum number of sets per night is two, but boats rarely make more than one set. While the net drifts, the captain and crew may sleep, awakening periodically to check for other boats in the vicinity of the net. Driftnets are occasionally run over and damaged by other boats and may even be severed by large vessels. The current is monitored by tracking the progress of the driftnet with Loran C.

Haulback usually starts before sunrise, taking 3-5 hours. This is accomplished with the help of a hydraulic hi-roller over which the net passes to be pulled onto the boat. Crewmen on either side of the boat pull and neatly stack the net on the aft deck after it has passed over the hi-roller. The catch is removed by the same crew pulling in the net. One strand of the mesh may have to be cut with a knife to remove gilled fish. Some fish may fall out of the net onto the deck in transit to the hi-roller. King mackerel and other commercially valuable species are thrown into a holding compartment or ice box. Ice is normally shovelled onto the catch several times during haulback. Unwanted fish are thrown overboard; most are dead when the net is hauled, though some fish are released alive. Upon completion of the haulback, the catch may be gutted and reiced at sea or left on ice and gutted by the crew at the dock before being weighed. At the fish house, gutted fish are bulk weighed, placed in chill tanks of ice water for several minutes, and packed on ice.

Catches and Landings

Observed Discarded By-Catch

By far the largest, proportion of the discarded by-catch was made up of little tunny, *Euthynnus alletteratus*, called "bonito" by the fishermen (Table 2). Little tunny made up 67.0 percent of the discarded by-catch and 23.1 percent of the total catch (landed plus discarded), by number. Barracuda, *Sphyraena* sp., the next most abundant fish in the discarded by-catch, made up 10.8 percent of the discards and 3.7 percent of the total catch. Each of the other species in the discarded by-catch made up 3.6 percent or less of the discards and 1.2 percent or less of the total catch.

Twenty-two sailfish, *Istiophorus platypterus*, were caught on the observed trips for an average of 0.58 sailfish per trip. On one trip, seven sailfish were caught, though such multiple catches on a single trip were rare.

No marine mammals or birds were observed entangled in the nets on any trip. Porpoises and sea turtles were observed in the vicinity of the nets on haulbacks on numerous trips. On one trip a leatherback sea turtle, *Dermochelys coriacea*, was observed by fishermen in a net at haulback. However, by the time the observer reached the stern, the turtle had freed itself and swam away before the net could be pulled from the water.

Observed Landed Catch

Fifteen species made up the observed landed catch of the driftnet boats. The most abundant fish in the landed catch was the target species, king mackerel, which made up 91.6 percent of the landed catch by number and also by weight, while constituting 60.1 percent of the total catch (Table 3). The next most abundant species in the landed catch was blue runner, *Caranx crysos*, which made up only 2.0 percent by number, 1.0 percent by weight of the landed catch, and 1.3 percent of the total catch by number. Each of the other species landed made up less than 2.0 percent of the landed and total catch by number or weight; most made up less than 1.0 percent.

About 4 percent of the king mackerel caught on the observed vessels were mutilated by predators, most likely sharks. Damaged mackerel that were salvageable were cut into chunks and sold or retained by the fishermen for personal use. The only other species that was observed to be mutilated was little tunny. It was not possible to determine how many fish were removed entirely from the nets by large predators. Large holes were observed frequently in the nets, presumably caused by large fish passing through. Most large sharks, with the exception of hammerheads, seem to be capable of ripping through the net. Fallout of gilled fish from driftnets was not possible to ascertain. No underwater fallout of fish from the net was observed during haulback, as visibility was limited to about 30 feet below the surface during morning daylight.

Table 3.—Landed catch of the driftnet boats carrying NMFS observers off Fort Pierce-Port Salerno, Fl., from May through September 1987. Numbers are based on 38 trips. Numbers in parentheses are fish counted but weight not included.

Species	Number landed	Weight landed (lb)	Percent of land. by no.	Percent of land. by wt.	Percent of total catch by no.[1]
King mackerel, *Scomberomorus cavalla*	4,831	46,325	91.6	91.6	60.1
Blue runner, *Caranx crysos*	106	487	2.0	1.0	1.3
Spanish mackerel, *S. maculatus*	93	367 (6)	1.8	0.7	1.2
Blacktip shark, *Carcharhinus limbatus*	67	478	1.3	0.9	0.8
Cobia, *Rachycentron canadum*	54	857 (4)	1.0	1.7	0.7
Sharks, var spp.	31	90 (1)	0.6	0.2	0.4
Blackfin tuna, *Thunnus atlanticus*	29	604 (1)	0.6	1.2	0.4
Red snapper, *Lutjanus campechanus*	21	64 (4)	0.4	0.1	0.3
Barracuda, *Sphyraena* sp.	15	90 (5)	0.3	0.2	0.2
African pompano, *Alectis ciliaris*	11	260 (1)	0.2	0.5	0.1
Crevalle jack, *Caranx hippos*	5	68	0.1	0.1	0.1
Wahoo, *Acanthocybium solanderi*	4	81	0.1	<0.1	0.1
Greater amberjack, *Seriola dumerili*	4	8	0.1	<0.1	0.1
Dolphin, *Coryphaena hippurus*	3	2 (2)	0.1	<0.1	<0.1
Tripletail, *Lobotes surinamensis*	1	— (1)	<0.1	<0.1	<0.1
Total	5,275	50,591			

[1]Total catch = landed plus discarded fish

Table 4.—Landed catch of seven mackerel driftnet boats, Fort Pierce-Port Salerno, Fl., April-September, 1987. Data are from 362 trips (50.1 percent of total 731 trips) and represent gutted weights.

Species	Pounds landed	Percent of total	Avg. lb. per trip
King mackerel, *Scomberomorus cavalla*	368,304	84.4	1,017.4
Blackfin tuna, *Thunnus atlanticus*	20,786	4.8	57.4
Sharks, var. spp.	18,174	4.2	50.2
Little tunny, *Euthynnus alletteratus*	7,146	1.6	19.7
Cobia, *Rachycentron canadum*	7,076	1.6	19.5
Weakfish, *Cynoscion regallis*	4,129	0.9	11.4
Spanish mackerel, *Scomberomorus maculatus*	3,322	0.8	9.2
Blue runner, *Caranx crysos*	2,214	0.5	6.1
African pompano, *Alectis ciliaris*	1,942	0.4	5.4
Bluefish, *Pomatomus saltatrix*	1,242	0.3	3.4
Wahoo, *Acanthocybium solanderi*	716	0.2	2.0
Dolphin, *Coryphaena hippurus*	586	0.1	1.6
Blue marlin, *Makaira nigricans*	328[1]	<0.1	0.9
Snappers, var. spp.	283	<0.1	0.8
Pompanoes, var. spp.	13	<0.1	<0.1
Total	436,261		

[1]Two fish, one 200 pounds, one 128 pounds (gutted weight).

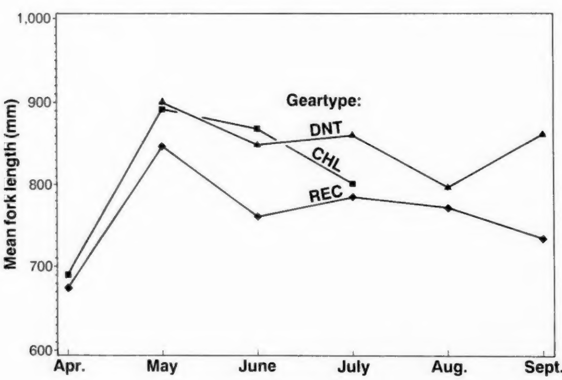

Figure 3.—Mean fork lengths of king mackerel from three gear types off the Fort Pierce-Port Salerno, Fla., area during 1987. DNT = driftnet, REC = recreational hook-and-line and headboat combined, and CHL = commercial hook and line.

Observed and Unobserved Landed Catch

Pounds of gutted weight of king mackerel landed by all driftnet boats were obtained by NMFS from fish-house records in the Fort Pierce (Saint Lucie County)-Port Salerno (Martin County) area for the 1986 and 1987 fishing seasons along with handline catches derived from records of the Florida Department of Natural Resources. Commercial king mackerel catches (all gear) from Saint Lucie and Martin counties increased by 516,741 pounds from 1986 to 1987. During the 1986 season, 465,430 pounds were taken by commercial gear. Driftnets took 208,472 pounds (45 percent) and handlines 256,958 pounds (55 percent) in the two counties where both gears were fished in 1986. In the 1987 season the commercial catch increased to 940,165 pounds with the landings from driftnets accounting for 771,066 pounds (78 percent) and from handlines 169,099 pounds (22 percent).

King mackerel landings from driftnet landings averaged 1,055 pounds per trip. Average mackerel landings by boat varied from 602 to 1,780 pounds among the boats fishing the entire season. One August trip landed 9,831 pounds.

By-catch data from seven boats fishing driftnets, but not observed, were obtained (Table 4). These data represented 362 of the total 731 trips made in 1987. Blackfin tuna, *Thunnus atlanticus*, and sharks represented the most common by-catch landings, although making up only 4.8 and 4.2 percent of the total catch by weight, respectively. Two blue marlin, *Makaira nigricans*, were also landed; no other billfish were landed. One species in reported by-catch landings and not in by-catch landings on observed trips was little tunny. This species was always discarded on observed trips. Whether this and other by-catch species were landed or discarded appears to have been influenced by price and other factors on a boat-by-boat basis.

Lengths of Fish

The mean fork lengths from king mackerel taken in three fisheries during 1987 are shown in Figure 3. Drift-

net caught fish (DNT) were measured by NMFS observers, headboat caught fish were measured by NMFS headboat samplers, commercial hook-and-line (handline) caught (CHL) fish were measured by a NMFS port agent and recreational hook-and-line caught fish lengths were collected by the NMFS Marine Recreational Fishing Statistics Survey. Recreationally caught fish (REC) were derived from combining headboat and recreational hook-and-line. The lengths of fish caught by different gear types differed, most likely due to the selectivity of the gear. Recreationally caught king mackerel were, on average, smaller than driftnet caught fish. Average lengths of commercial hook-and-line catches seemed to parallel the driftnet catch in the early season, but were smaller than those in July.

Table 5.—Cost data for mackerel driftnet trips off Fort Pierce-Port Salerno, Fl. Data were collected for five vessels (A-E) fishing in the summer of 1987.

Item	Vessel A	Vessel B	Vessel C	Vessel D	Vessel E
Cost of net	$17,500	$12,000	$12,000	$17,000	$12,000
Life of net	72 mo.	72 mo.	84 mo.	60 mo.	84 mo.
No. of crew incl. captain	4	3	3	3	3
Pay shares	50% crew 40% boat 10% net	60% crew 40% boat	60% crew 40% boat	60% crew 40% boat	45% crew 40% boat 10% net 5% supplies
Fuel consumption/trip	50 gal.	35 gal.	45 gal.	50-75 gal.	50-55 gal.
Fuel cost/trip	$50	30	$30-35	$40-60	$45
Ice cost/trip	0	0	$25-50/wk	0	0
Other costs/trip	$15	$20	$10-15	$15	$100/wk

Economic Data

Average net cost, crew size, and average trip cost for five different boats fishing driftnets full time in 1987 are shown in Table 5. Most boats were using nets that were purchased new in 1986 or 1987. The nets cost from $12,000 to $17,500 rigged, depending on their length, and are expected to last 6-8 years. All boats pay the crew a percentage of the catch. Normally the boat gets 40 percent of the revenues off the top and the crew divides the remainder equally. A few boats have a "net fund," usually 10 percent, that is held back from each paycheck and is used for net repairs. At the end of the season any money remaining in the net fund is split among the crew.

Trip costs are relatively low because there is little fuel consumption (average 40-60 gallons per trip or 200-250 gallons per week) due to the fact that most of the time is spent drifting. Ice is used, but is generally provided to the boats by the processors free of charge. The only other significant trip expenses are food and beverages (usually a case of soda per trip) which cost about $10-$20 per trip. By far the major expense in this fishery is the initial capital investment in the net.

Ex-vessel prices for king mackerel ranged from $0.92 to $1.50 per pound for net-caught fish during the 1987 season. Hook-and-line caught fish usually brought $0.20 more per pound. Although there have been claims that net-caught fish were of inferior quality, most dealers have stated that there is no problem with the quality of net-caught fish. Fishermen generally decreased driftnet soak time in the summer to maintain quality of king mackerel as water temperatures increased.

Acknowledgments

We thank Edwin Irby and Robert Muller of the Florida Department of Natural Resources, Cecil Lane of Hudgins Fish Company, Fort Pierce, Bob Crane, C & W Fish Co., Port Salerno, and Glen Black, Inlet Fisheries, Fort Pierce, for assistance in obtaining catch data. We also thank the participating captains for their cooperation and Southeast Fisheries Center personnel for serving as observers.

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NOAA Employees Awarded Gold and Silver Medals

Twenty-six U.S. Department of Commerce Gold and Silver Medals were awarded to NOAA employees at the Department's annual honor awards ceremony in Washington, D.C., 18 October 1988. The Gold Medals are given "for rare and distinguished contributions of major significance to the Department, the Nation, or the world." Earning them were: William E. Carter, NOS, Rockville, Md., for contributions to the conception, founding, and operation of the International Earth Rotation Service. Kikuro Miyakoda, William F. Stern, Joseph J. Sirutis, and M. Daniel Schwarzkopf, Environmental Research Laboratories, Princeton, N.J., for research to improve components of atmospheric models and cooperative efforts to implement them in operational weather forecasts. Melvyn A. Shapiro, Environmental Research Laboratories, Boulder, Colo., for contributions to the understanding of complex meteorological phenomena. And, W. David Rust and Vladislav Mazur, Environmental Research Laboratories, Norman, Okla., for contributions to the understanding of atmospheric electrification and contributions to the nation's space program.

Silver Medals "for meritorious contributions of unusual value to the Department or the Nation" were awarded to: Michael L. Tucker, Office of Administration, Kansas City, Mo., for leadership in organizing and developing a combined Department of Commerce/Department of Agriculture National Logistics Supply Center. Lt. (j.g.) Edward R. Cassano, NOAA Corps, and Daniel Granstrom, NOS, for skill and courage in fighting a fire on the NOAA Ship Miller Freeman. Lloyd D. Huff, NOS, Rockville, Md., for developing an advanced water vapor radiometer under the Department's Small Business Innovation Research Program leading to a very successful business activity.

NMFS Silver Medalists were Daniel D. Huppert, La Jolla, Calif., for his innovative concepts in the application of economic principles to the management of marine fisheries, and Dennis M. Weidner, Washington, D.C., for furthering the long-term U.S. policy of developing a cooperative fisheries relationship with Mexico.

Other NOAA recipients were Kenneth C. Crawford, NWS, Norman, Okla., for pioneering efforts in transferring new technologies into operational meteorology. Alan R. Moller, NWS, Fort Worth, Tex., for implementing public preparedness programs and developing and conducting training sessions on severe weather. Gerald S. French, NWS, Portland, Maine, for timely and accurate forecasts preventing great loss of life and property in Maine during flooding in April 1987. Joseph P. Gerrity, Jr., NWS, Camp Springs, Md., for leadership and achievement in atmospheric global numerical modeling. Johnny S. Smith, NWS, Kansas City, Mo., for successful completion of the Computerized Marine Weather Data System on the Great Lakes. D. Gregory Harmon, NWS, Salt Lake City, and Christopher E. Fontana, NWS, Reading, Calif., for developing the concept of an air transportable mobile fire weather unit. Robert C. Kilpatrick and Timothy E. Scrom, NWS, Albany, N.Y., for their outstanding weather forecasts and warnings during New York flooding in April 1987. Michael J. Nestlebush, NESDIS, Camp Springs, Md., for leadership, management, and technical guidance in improving NOAA's Geostationary Environmental Satellite Data Collection System. Michael Crowe, NESDIS, Asheville, N.C., for leadership in development of automated climatological data processing systems. And, National Oceanographic Data Center, NESDIS, Washington, D.C., for excellence in ocean data management through quality improvement and increased productivity.

Stansby Honored; Burton, Tillman, Angelovic Named

The National Oceanic and Atmospheric Administration (NOAA) dedicated its new Fish Oil Biomedical Test Materials Laboratory in South Carolina in honor of Maurice E. Stansby in September 1988. The new facility, a part of the Charleston Laboratory of the National Marine Fisheries Service's Southeast Fisheries Center, is located at 217 Fort Johnson Road, P.O. Box 12607, Charleston, SC 29412-0607.

Stansby is a recent recipient of the President's Award for Distinguished Federal Civilian Service for his many years of pioneering research on the chemistry and biochemistry of fish oils which has aided in the understanding of the health benefits of fish oil in the human diet. The new Fish Oil Biomedical Test Materials Laboratory was built to insure that standardized, quality-assured test materials would be available for use in biochemical and clinical studies over a multi-year time frame.

Also in September, B. Kent Burton was sworn into office as Assistant Secretary of Commerce for Oceans and Atmosphere at the National Oceanic and Atmospheric Administration, succeeding J. Curtis Mack II, who resigned to return to California. Burton had been director of the Office of Legislative Affairs for the Commerce Department agency since 1984.

In addition, Michael F. Tillman was

chosen to fill the NMFS Senior Scientist position. He is charged with preserving and enhancing the scientific vitality of NOAA's fisheries-related activities. And, Joseph W. Angelovic was appointed to the position of Science and Research Director, NMFS Southeast Region, effective 25 September 1988. Angelovic also continued as Acting Director of the Region until a new Regional Director is named.

NOAA Aids Rescue of Gray, Beluga Whales

Late last fall, while NOAA scientists and others struggled to save two gray whales trapped in ice off Point Barrow, Alaska, another rescue operation saved 27 beluga whales off Anchorage, Alaska. The Anchorage incident at Cook Inlet occurred on Sunday, 23 October, according to the National Marine Fisheries Service. The small white whales were a part of an isolated population of the species in that area numbering an estimated 500-1,000 animals.

The belugas were believed to have stranded as the tide went out during the late morning or early afternoon. Notified by an environmental group, two NOAA scientists and a veterinarian quickly helicoptered to the area, which is surrounded by quicksand-like mudflats. Two local kayakers had already begun the process of keeping the animals wet with blankets and buckets of water.

When the tide finally reached the whales, they became excited and, as soon as the water covered them, swam away. When last seen, all 27 animals (three calves, four yearlings, and twenty adults) were swimming in a normal manner. None of the whales was believed to have died. There are about 30 whale strandings yearly in Alaska and the NMFS has established a statewide stranding network to respond.

But it was "Operation Breakthrough" that caught the world's attention off Point Barrow where, initially, three gray whales had become trapped in the ice. The episode began in early October with the discovery of the three whales by a hunter. By 14 October, the two breathing holes used by the whales had shrunk from "basketball court" size to about 15×30 feet, and the nearest open water was almost 5 miles away. Efforts to secure a hovercraft barge to cut a channel for the whales were stymied by technical problems and an impregnable 30-foot-high pressure ridge. Ron Morris, with the NMFS office in Anchorage, and Eskimos began using chain saws on 15 October to enlarge the shrinking breathing holes.

On 19 October workers began to cut new holes, hoping to lead the whales toward open water; two volunteers from Lakeland, Minn., arrived with six water circulation pumps which proved vital in keeping the breathing holes open. On 21 October, Under Secretary William Evans learned of two Soviet icebreakers in the vicinity and with State Department help, requested their assistance. Two vessels, the 443-foot *Admiral Makarov* and the 518-foot *Vladimir Arseniev* were volunteered. By then, though, the smallest of the whales was no longer surfacing and was presumed dead.

By the 22nd, a string of 55 holes had been opened, but the whales refused to cross a shallow, 12-foot deep area. The same day, Rear Admiral Sigmund Petersen, Director of NOAA's Pacific Marine Center and aide LCDR Terry Jackson arrived in Barrow to coordinate rescue logistics, and an Air Force C-5XA cargo plane brought in an Archimedean Screw Tractor to the site for ice cutting. On the 24th, the ice crew in Barrow connected a series of holes to create a single open channel about 600 yards long which allowed the whales to roll and breathe more normally.

On the 25th the Soviet icebreakers began attacking the pressure ridge, new holes were cut by the ice crew to bypass the shallow area, and by nightfall, the *Arseniev* was within ¼-mile of the whales. On the 26th, the *Arseniev* came within 200 yards of the whales. On the 27th, the Soviets made their last passes through the ice, and lights and pumps were shut off at nightfall to eliminate any stimulus that might hold the whales. On Friday the 28th, Eskimos at the breathing hole watched the whales surface at 8:45 a.m. and head toward the open water—the last time they are seen; favorable weather and ice conditions continued for the next several days. Finally, on 5 January 1989, 17 groups and individuals that played key roles in the rescue were honored at a Washington, D.C., ceremony by Commerce Secretary C. William Verity and Under Secretary William E. Evans.

Summer Flounder FMP Approved

Richard B. Roe, Northeast Regional Director of the National Marine Fisheries Service (NMFS), announced in September 1988 that the Fishery Management Plan for the Summer Flounder Fishery (Plan) had been approved. The Mid-Atlantic Fishery Management Council developed the Plan which has objectives of reducing fishing mortality on immature summer flounder, increasing long-term yield from the fishery, improving uniformity of management between state and Federal waters, and minimizing regulations to achieve these goals. Final regulations were to become effective on 3 November 1988, implementing the following management measures:

1) It will be illegal for those issued a Federal fisheries permit to fish for summer flounder, or to possess or land summer flounder or flounder parts which are smaller than 13 inches in length.

2) If a state has established a minimum size for summer flounder which is larger than 13 inches, the state's size limit will prevail.

3) Foreign fishermen will not be able to take summer flounder.

4) Both commercial vessels and recreational vessels landing more than 100 pounds (party and charter boats) fishing for summer flounder in Federal waters will have to obtain an annual permit.

5) Those states with more restrictive regulations pertaining to net mesh sizes and minimum summer flounder sizes will be encouraged to maintain them.

6) Three years after the Plan goes into effect, the Council will determine whether it is working to reduce fishing mortality. If it is not working, a 14 inch minimum fish size may be established.

"All measures, including the Permit requirement, will be enforced beginning 3 November 1988," Roe said.

Shellfish Raids, Arrests Made in U.S. Southeast

Culminating a year long undercover investigation by National Marine Fisheries Service, U.S. Food and Drug Administration, and state conservation agencies, 16 Federal warrants and 9 state warrants were served in Louisiana, Florida, and South Carolina in September 1988. The tri-state raid teams consisted of 20 NMFS agents, 9 FDA investigators, and 58 officers from the Florida Department of Natural Resources, Florida Marine Patrol, South Carolina Wildlife and Marine Resources Division, South Carolina Department of Health and Environmental Control, and the Louisiana State Police.

The NMFS, FDA, and state law enforcement agencies initiated the multistate investigation as a result of numerous complaints and information that illegal shellfish products were being harvested and sold in interstate commerce. Harvesters and dealers allegedly handled oysters and clams taken from polluted waters and were buying and selling products without regard to state tagging requirements. The harvesting of oysters and clams from polluted areas, improper temperature storage, or the purchase and sale of untagged shellstock is tantamount to a potential catastrophe.

Suzanne Montero, Special Agent In Charge, NMFS, St. Petersburg, Fla., and Robert Bartz, District Director, FDA, New Orleans, La., announced that the joint law enforcement effort was mandated by considerations of safety to the public health. The size and nature of the problem led the government officials to believe the investigation could not be handled through regular law enforcement means, but required the cooperative efforts of state and Federal agencies in a major undercover investigation. Operations PEARL (La.), STOP (Fla.), and SPONGE (S.C.) allowed undercover state and Federal agents to enter the world of black-market oyster and clam dealers to document their illegal activities.

Ten search warrants were served on oyster dealers in Louisiana and Florida, while nine arrest warrants were served on clam dealers in South Carolina. In addition to thousands of anticipated state charges, the alleged Federal violation is the Lacey Act, 16 U.S.C. 3371-3378. The statute states, in part, that it is illegal to import, export, transport, sell, receive, acquire, or purchase in interstate commerce any fish or wildlife taken, possessed, transported or sold in violation of any law or regulation of any state. The maximum felony penalty for knowingly violating the law, if convicted, is up to $20,000 or 5 years incarceration or both per count.

Atlantic Billfish FMP Approved, Challenged

The Fishery Management Plan for the Atlantic Billfishes (FMP) was approved in September 1988 by the Secretary of Commerce, according to Joseph W. Angelovic, Acting Director, Southeast Region Office, National Marine Fisheries Service. The FMP was developed by the South Atlantic Fishery Management Council in cooperation with the New England, Mid-Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils. The principal objective of the FMP is to maintain the highest availability of billfishes to the traditional recreational fishery by reducing commercial and recreational fishing mortality on billfishes. The final rule implementing the FMP was published in the *Federal Register* on 28 September 1988 and was scheduled to become effective on 28 October 1988.

The regulated species are blue marlin, white marlin, sailfish, and longbill spearfish. The rule regulates: 1) Fishing for and possession of billfish aboard a vessel of the United States shoreward of the outer boundary of the exclusive economic zone (i.e., in Federal and state waters from 0-200 n. mi.) in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea, and 2) possession and sale in any state of a billfish harvested from its management unit. Management units are defined as follows: 1) Blue marlin and white marlin—North Atlantic Ocean north of lat. 5°N; 2) Sailfish—North and South Atlantic Oceans west of long. 30°W; and 3) longbill spearfish—the entire North and South Atlantic Oceans. The Gulf of Mexico and Caribbean Sea are included in all management units.

The major provisions of the rule include:

1) Prohibition of sale in the United States of a billfish harvested from its management unit. Seafood dealers possessing billfishes harvested prior to 28 October 1988 would be given until 27 December 1988 to sell or dispose of those fish. A requirement that any billfish possessed by a seafood dealer or processor must be accompanied by documentation that it was harvested from an area other than its manage-

ment unit was scheduled to become effective on 27 December 1988, pending approval by the Office of Management and Budget.

2) Minimum size limit (expressed in terms of length from the tip of the lower jaw to the fork of the tail) for blue marlin is 86 inches; white marlin, 62 inches; sailfish, 57 inches.

3) Prohibition of possession of billfishes by pelagic longline and drift net vessels.

4) Restriction of possession or retention of billfishes to those caught by rod and reel.

5) Mandatory reporting of catch and effort information from selected billfish tournaments.

For copies of the rule or for further information, contact Rodney C. Dalton, NMFS Southeast Regional Office, St. Petersburg, Fla., or phone 813-893-3722.

(On 26 October 1988 the billfish regulations were challenged in Federal district court by the National Fisheries Institute and the Southeast Fisheries Association, contending that the measures were in violation of the Magnuson Fishery Conservation and Management Act and the Administrative Procedures Act.)

Major Pacific Current May Be Key to El Niño

The eastward flow of a major equatorial current in the Pacific Ocean was interrupted and reversed for about a month in late 1987, and may have signalled the end of the 1986-87 El Niño event, according to National Oceanic and Atmospheric Administration (NOAA) oceanographers. During September and October 1987, the Equatorial Undercurrent was observed in the western Pacific to be flowing west at speeds of about half a mile an hour, Michael McPhaden of NOAA's Pacific Marine Fisheries Environmental Laboratory in Seattle said. Normally the current, about 150-800 feet below the ocean surface, about 275 miles wide, and spanning the breadth of the Pacific along the Equator, flows eastward at about 1 mile an hour.

The Undercurrent, McPhaden explained, is created when the tradewinds, which usually blow from east to west, pile up surface waters in the western Pacific. The weight of the piled up water causes pressure on subsurface waters to be higher in the western Pacific than in the eastern Pacific. This pressure difference forces water to flow eastward a few hundred feet below the surface. When the tradewinds weaken, as happens during an El Niño event, the warm surface waters migrate eastward, reducing the amount of piled up water in the western Pacific, therefore the pressure difference between east and west. When this occurs, the Undercurrent flow may reverse.

The westward flow of the Undercurrent, McPhaden speculated, may have been an indicator that the El Niño was ending. It began in the summer of 1986 and was over by the end of 1987. El Niños occur irregularly every 2-7 years, last for 1-2 years, and are involved in global climate fluctuations. During an El Niño, warm surface waters from the western tropical Pacific migrate eastward along the equator towards the International Dateline.

"Perhaps," McPhaden noted, "the origin of El Ninõ's demise may be found in the weak winds which typify it at its peak." This was the first clear documentation of an El Niño-related major disruption of the Undercurrent in the western Pacific, McPhaden said. During the 1982-83 El Niño, the Undercurrent disappeared in the eastern and central equatorial Pacific, but it is not known whether the western Pacific was similarly affected. The latest findings are based on moored current meter measurements collected since January 1986 as part of a joint effort between the United States and the People's Republic of China to study air-sea interaction in the western Pacific.

"The magnitude of this event can be appreciated by noting that the volume transport of the Undercurrent—about 800 million gallons per second—is comparable to that in the Florida current which feeds the Atlantic Ocean's Gulf Stream," McPhaden said. The event suggests potentially important implications for understanding climate disturbances associated with El Niño, he added, noting that the global climate system is particularly sensitive to variations in the warm, western tropical Pacific surface layer.

Yellowfin Tuna Embargo

The United States embargoed all yellowfin tuna from Ecuador, Panama, Venezuela, and the Pacific Island nation of Vanuatu in October 1988 because those countries failed to provide evidence that they were catching tuna in accordance with U.S. regulations aimed at reducing the accidental killing of porpoises. The embargo went into effect 16 October according to the National Marine Fisheries Service, which is responsible for protecting marine mammals.

NMFS said the value of yellowfin tuna imported from those countries in 1987 was almost $30 million. However, economists with the agency said they could not assess the economic impact of the embargo on the United States because other sources of tuna may become available. Mexico, which is complying with the U.S. standards and will be unaffected by the embargo, sent 19 percent of its yellowfin tuna to the United States last year, NMFS reported. Total imports of all tuna to the United States were worth $457 million last year. An estimated 20 percent of that was yellowfin.

The yellowfin tuna, found in the eastern tropical Pacific, tend to swim with porpoises. When tuna fishermen enclose both porpoises and tuna in their huge seine nets, the porpoises can become trapped and drown. Since 1981 the United States has set a limit of 20,500 porpoises that could be accidentally killed each year by the domestic tuna fleet. Last March, NOAA issued regulations that require foreign countries to provide evidence that their tuna fisheries have programs to protect porpoises comparable to that of the United States.

Mortality Very High for Georges Bank Cod

Fishing pressure for Atlantic cod, *Gadus morhua*, on Georges Bank significantly intensified in 1987 resulting in the highest fishing mortality rate ever recorded for this fish stock, according to a Northeast Fisheries Center stock assessment evaluation in fall 1988. Fredric M. Serchuk, the Center scientist who conducted the evaluation, notes that, "High fishing effort is keeping cod numbers at record-low levels and minimizing the number of fish available to spawn."

The Northeast Fisheries Center is the research arm of NOAA's National Marine Fisheries Service for the northeastern United States. Serchuk is Chief of the Center's New England Offshore Fishery Resources Investigation which monitors and evaluates the status and condition of finfish and shellfish resources in the Georges Bank and Gulf of Maine regions.

Serchuk emphasizes that, "Fishing mortality in 1987 was so high that only about 30 percent of the Georges Bank cod that were alive at the beginning of 1987 survived to the beginning of 1988. Where such high fishing mortality has been maintained on cod stocks in other areas of the world, stock collapses have occurred." Serchuk characterized the status of the Georges Bank cod stock as "precarious."

Cod is important in both commercial and recreational fisheries in New England. Of the 26.6 thousand metric tons (58.6 million pounds) of cod landed by New England commercial fishermen in 1987, 19.0 thousand metric tons (42.0 million pounds) came from Georges Bank, with a landed value of about $32 million. Recreational catches in 1987 from the Georges Bank stock exceeded 2,900 metric tons (6.4 million pounds).

Recently completed analyses indicate that the spawning stock (mature fish) of Georges Bank cod is depressed and at an all-time low. For the fifth consecutive year, spawning stock size declined. At the beginning of 1988, spawning stock biomass (the aggregate weight of all spawners in the population) was only 30.9 thousand metric tons (68.1 million pounds), the lowest value in the 11 years that such statistics have been computed. The present spawning stock size is only one-third of that observed in 1980.

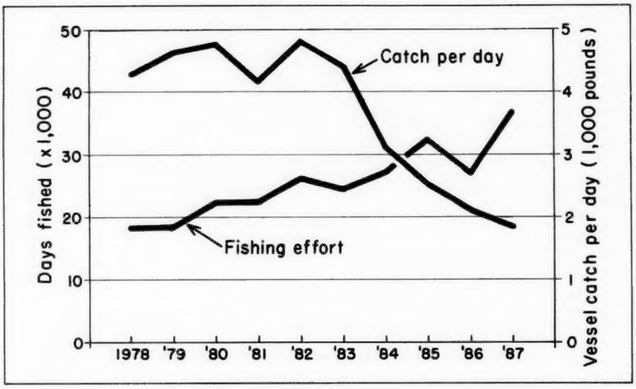

Figure 1.—Trends during 1978-87 in fishing effort for, and average catch per day per vessel of, Georges Bank cod.

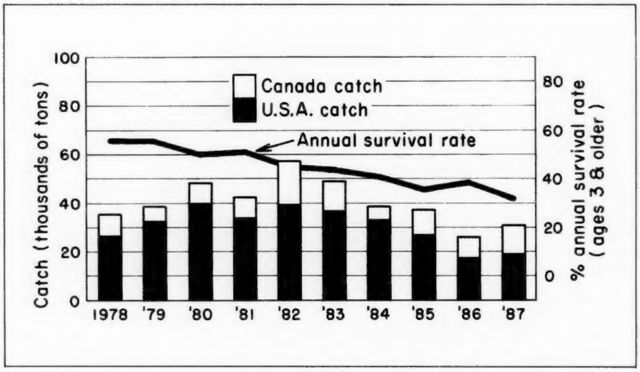

Figure 2.—Trends during 1978-87 in both the annual survival rate and the annual catch of Georges Bank cod. Survival rate is depicted for fish that are 3 years old or older (the ages that are fully vulnerable to commercial fishing operations) and is measured on the righthand percent scale. Annual catch is partitioned into U.S. and Canadian catches, and is measured on the lefthand scale in thousands of metric tons (one metric ton equals 2,205 pounds).

Northeast Fisheries Center staff estimated that the 1988 U.S. commercial catch of Georges Bank cod would be about 23.8 thousand metric tons (52.5 million pounds), about 25 percent higher than in 1987. The increased 1988 catch would result from continued record high fishing effort and from the above-average number of cod hatched in 1985 (the 1985 year class) which have/will reach a size at which they are fully vulnerable to commercial fishing operations.

At the current fishing mortality rate,

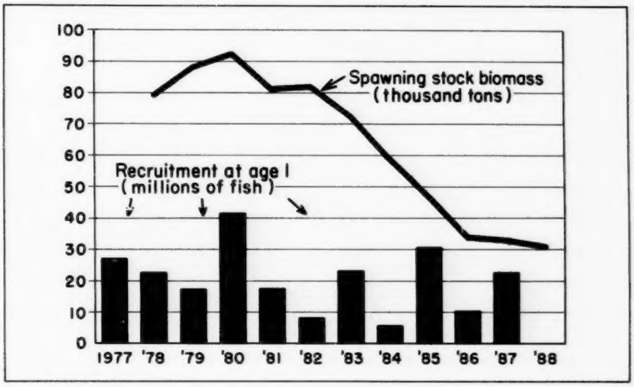

Figure 3.—Trends during 1978-87 in spawning stock biomass and recruitment at age 1 for Georges Bank cod. Spawning stock biomass is measured in thousands of metric tons. For the bars representing recruitment at age 1, the year underneath each bar is the year that the cod were hatched; the height of the bar depicts how many millions of those fish survived to age 1 in the following year.

however, the 1985 year class will be quickly depleted. The 1989 fishery will then primarily depend on fish hatched in 1986 and those fish hatched in 1987 that have grown large enough to be caught by commercial fishing gear. Catches in 1989 are likely to drop dramatically since the 1986 year class is a poor one. Although the 1987 year class presently appears strong, continued high fishing mortality and dependence by the fishery on young, mostly immature fish (ages 2 and 3) will prevent any rebuilding of the spawning stock from the current record-low levels.

Serchuk adds that "Cod is the predominant species landed in the U.S. Atlantic coast groundfish fishery, generally accounting for more catch, by weight, than any other species. The sharp decline in the size of the Georges Bank stock to a level well below its normal historical range is a cause for major concern with regard to the future of this valuable resource."

Juvenile Snapper Habitat

Determining where juvenile deepwater snappers reside off Hawaii may not be one of life's great mysteries. But it is a question that has stumped scientists for years, according to George W. Boehlert, Director of the Honolulu Laboratory of the NMFS Southwest Fisheries Center.

The habitat of juvenile deepwater snappers was recently documented by Jeffrey J. Polovina, a fishery scientist with the Honolulu Laboratory. In October 1988, scientists caught three species of juvenile deepwater snappers—lehi, uku, and opakapaka—by hook and line outside Kaneohe Bay, Oahu, in the Hawaiian Islands. This study site was selected based on information obtained from a recreational fisherman who reported catching juvenile snappers occasionally while fishing there for wrasse. "Knowing the habitat type where juvenile snappers can be found fills a major gap in the life history of the deepwater snappers," said Polovina.

The habitat of juvenile deepwater snappers is hard, flat coral covered by a thin veneer of sand and is in relatively shallow (40-70 m) water. Conversely, adult snappers prefer steep, rocky sites in deeper water (about 200 m) and with lots of vertical relief.

Ironically, a few years ago, this same juvenile habitat site was one of the sites considered by Honolulu Laboratory scientists for placing an artificial reef to provide habitat for adult deepwater snappers. Initial fishing and visual censuses had suggested this flat, sandy habitat was devoid of fish larvae. However, using a different sampling method (hook and line) resulted in finding an abundance of juvenile snappers.

"This is an interesting ecological lesson," said Polovina. "When you sample an area and don't catch fish, don't immediately assume that there are no fish. Nature has a way of taking care of things . . . something will move into that niche."

"An artificial reef could have provided additional habitat for taape, a predator of juvenile snappers, thereby increasing the predators while decreasing habitat for juvenile deepwater snappers," said Polovina.

Documenting the juvenile habitat of these valuable commercial snappers is an important step in completing our knowledge of their life history. Now that scientists know the type of habitat juvenile snappers prefer, they can begin to determine when and where the juvenile deepwater snappers are located, thereby gaining insight into the recruitment patterns to the fishery. Such information ultimately will be extremely useful in managing the snapper fishery. The deepwater snapper fishery is one of Hawaii's most valuable fisheries, said Polovina. Commercial fishermen in 1987 landed 1.8 million pounds of deepwater snappers valued at $5.3 million.

Drift-net Problems Hit South Pacific

Like video games and hamburgers, drift gill-net fishing (drift-netting) is becoming commonplace throughout the world. Its latest emergence is in the relatively unfished waters of the South Pacific by Taiwanese and Japanese drift-net fleets targeting surface schools of albacore. Concerned fishery officials of several South Pacific island countries met in Suva, Fiji, on 3-4 November 1988 to discuss ways to discourage the use of drift nets on the high seas of the South Pacific, according to George W. Boehlert, Director of the NMFS Southwest Fisheries Center's Honolulu Laboratory.

"This highly effective fishing technology brings with it considerable controversy and a host of knotty problems for fishermen, marine scientists and government fishery managers," said Jerry A. Wetherall, an albacore expert and Chief of the Honolulu Laboratory's Pelagic Resources Investigation, who attended the meeting. "One of the main problems is that drift nets entangle and kill other marine life occurring in the same area as the target fish species."

"Drift-net fishing occurs legally on the high seas, so the South Pacific fishery officials considered means to discourage drift-netting in the region by reducing economic incentives," said Wetherall. Albacore are the premium species of tuna for canning and a resource of considerable interest to South Pacific islanders.

Albacore gill-netting on the high seas is economically attractive to its proponents because nets 15 miles or more in length, reaching from the sea surface down to 30 feet, can be set in the water, left to drift in the current overnight and hauled in at relatively low cost. The nets are made from multifilament nylon and have meshes about 7-8 inches wide.

Large albacore have been harvested for 30 years in deep waters of the South Pacific by fleets of longline fishing vessels from Japan, Taiwan, and Korea operating out of ports in Asia or the South Pacific. Recently it was discovered that smaller albacore could be caught in a narrow zone of the South Pacific stretching from New Zealand to Chile near lat. 40°S. In this area, water of the temperature preferred by albacore occurs at the sea surface, coincident with a zone relatively rich in forage. Albacore aggregate here to feed and are vulnerable to surface trolling and drift-netting as well as longlining.

Two trollers from the United States began a fishery in the area in 1986, followed by 7 trollers in 1987. In the 1988 fishing season, a fleet of 41 U.S. vessels was joined by trollers from Canada, Fiji, and French Polynesia. The troll fishery was so successful that several South Pacific island countries consider it a promising avenue for local economic development.

In 1988 drift-net fishing began on a small scale in the same area fished by the trollers. However, during the upcoming 1989 fishing season, January through April, the fleet of drift-net boats is expected to grow to as many as 80 vessels, each with a capacity of 200-300 tons of albacore. There is some concern that the increased catch of albacore by drift-net vessels, when combined with the catch already taken by longline and trolling fleets, may exceed the maximum sustainable yield of the population.

This situation is complicated by the fact that the actual mortality caused by drift-net fishing may be substantially greater than the observed catch. Some of the fish and other marine life entangled in the nets drop out during fishing and retrieval of the nets, and an unknown fraction of albacore dropping out die as a result of the encounter. Others suffer cuts and abrasions that reduce their value to troll and longline fishermen who may catch them later.

Troll fishermen also report that albacore behavior is affected by encounters with drift nets, reducing the effectiveness of troll fishing. The incidental mortality associated with albacore drift-netting in the South Pacific is also a potential problem. The incidental catch may include marlin, swordfish, seabirds, sea turtles and marine mammals. Such species as the southern fur seal and beaked whale may be at risk. Other methods of catching albacore, such as trolling or longlining are not detrimental to seabirds, sea turtles or marine mammals.

Another major problem caused by drift nets is the hazard they impose to fishing vessels and fishermen at sea. The nets are operated at night and are set at the water's surface, where they can easily entangle the propellers of vessels. Trolling vessels, and even the drift-net vessels themselves, have become disabled by drift nets. Fishermen are endangered when they are forced to dive under the vessel to cut the boat free. During gill-netting trials a few years ago in waters north of Australia, two Japanese fishermen drowned in such an effort.

The Suva meeting, which was

Connecticut Earns Sea Grant College

The University of Connecticut was designated a "Sea Grant College," the 23rd institution in the nation to receive the distinction, at a ceremony in Groton on 5 October. The designation recognizes the continuing responsibility exercised by the Connecticut Sea Grant Program since 1974 to develop and maintain excellence in marine resources research, education, and advisory/outreach programs.

Connecticut Sea Grant currently supports research programs in animal and plant aquaculture, coastal processes and engineering, mollusk population ecology/dynamics, marine economics, and tourism/recreation. Advisory and outreach programs address issues related to fisheries and seafood, aquaculture, environmental quality, and coastal development. The Sea Grant Program also provides funds for graduate education and a number of programs aimed at improving marine education.

called by the South Pacific Forum Fisheries Agency, was attended by representatives from American Samoa, Cook Islands, New Zealand, Fiji, French Polynesia, Tonga, and Vanuatu, as well as officials from the South Pacific Commission, the United Nations Development Program and South Pacific island fishing companies. Wetherall provided the group with technical information about the albacore resource and fisheries.

According to Wetherall, one of the means considered by the South Pacific fishery officials to discourage albacore drift-netting was for countries in the region to deny drift-net vessels access to their exclusive economic zones or ports for any purpose, such as reprovisioning, refueling, or transfer or delivery of catch.

"Another measure considered was for officials to persuade the canneries and transshipment facilities in the South Pacific to deal only in albacore caught by trollers and longliners, and not drift-netters," said Wetherall. The use of drift gill nets by foreign vessels has been banned within the 200-mile exclusive economic zone around Hawaii, Guam, and American Samoa. The actions taken by the South Pacific island countries add to the growing global resistance to drift-net fishing and show that concerns about negative effects of drift-netting exist even in the remote waters of the South Pacific.

Antarctic Ozone Drop Much Less Than in 1987

A springtime "ozone hole" which has appeared in Antarctica in recent years was considerably less deep in 1988 than it was in 1987, and even shallower than in 1986, the National Oceanic and Atmospheric Administration (NOAA) reports. Measurements with balloon-borne instruments launched by NOAA personnel at the South Pole in early October 1988 show that the amount of ozone in an air column above the site averaged more than 200 Dobson units, according to Walter Komhyr of the Commerce Department agency's Environmental Research Laboratories in Boulder, Colo.

Average early October values in 1986 and 1987 were 165 and 135 Dobson units, respectively; remarkably low ozone values for anywhere on earth, Komhyr said. If present trends continue, he noted ozone values during the latter half of October would approach those last observed at South Pole prior to 1980 when values on average during mid-to-late October were in excess of 250 Dobson units.

Ozone has been decreasing in the spring in Antarctica since the mid-to-late 1970's. Typically, the decrease each year begins in early September with ozone reaching minimum values in early October. The general downward trend has exhibited slight temporary ozone recovery in alternate years, with the largest recovery prior to 1988 occurring in 1986. The 1988 recovery was even larger.

The ozone hole occurs within the Antarctic polar vortex, a belt of strong west-to-east winds that circle the Antarctic during winter and spring months. Within the vortex in 1988, stratospheric temperatures at the South Pole in September and early October were 5°-10°C warmer than they were in 1987, and 2°-5°C warmer than in 1986. The warmer temperatures, Komhyr said, did not favor the formation of polar stratospheric clouds in 1988, as did the colder temperatures in previous years.

Stratospheric clouds promote the photochemical destruction of ozone by chlorine compounds derived from man-made chlorofluorocarbons. Polar stratospheric clouds form at temperatures colder than about −78°C. The ozone readings this 1988 austral spring in the Antarctic do not mean that the threat of reduced ozone levels globally no longer exist, Komhyr emphasized, nor does it portend the end of the Antarctic ozone hole. Rather, he said, the readings indicate that large year-to-year changes in ozone can occur from natural variations in atmospheric processes. The ozone monitoring program at South Pole is conducted by NOAA in cooperation with the National Science Foundation which is the agency responsible for the United States Antarctic Program.

Sea Turtles Dying Along SE Beaches

Record numbers of Kemp's ridley turtles were washing up dead on Florida and Georgia beaches late in 1988, according to scientists at the National Oceanic and Atmospheric Administration's (NOAA) Southeast Fisheries Center in Miami. Between about 13 October and early December, according to NOAA, at least 62 of the turtles were found dead.

"This increase doesn't mean that the overall turtle population has risen," said Nancy B. Thompson, turtle biologist at the Center. "Instead, we suspect that there has been an unusual aggregation of Kemp's ridleys in this area, likely a result of the availability of crabs and scallops, their principal food." According to Thompson, the number of dead turtles had continued to grow almost daily, and represented nearly an eightfold increase over the average number found on the same beaches in past years.

NOAA scientists were examining satellite images of the area to see if unusual weather or other environmental conditions might explain the deaths. Other possibilities, including drowning in fishing gear or inside dredging equipment and deliberate injury by humans, were also being looked at. Turtles can easily become trapped and drown inside the funnel-shaped nets of shrimp boats, NOAA said.

None of the turtles found on the beaches was still alive, Thompson reported, and only a few showed any sign of external injury. Most had begun to deteriorate. In addition to the Kemp's ridleys, the leatherbacks and 15 loggerhead turtles were recovered by scientists and concerned citizens, bringing the total number of stranded turtles to almost 80. One of the leatherback turtles was reportedly entangled in fish netting.

All the species of sea turtles found in U.S. waters are protected by Federal law and are listed as either threatened or endangered. The Kemp's ridley has been the subject of considerable research at the Miami Center in

the past decade. It is the most endangered of all sea turtles and nests almost exclusively on a single beach in Rancho Nuevo, Mex. In 1980, the Center assembled a Sea Turtle Stranding and Salvage Network involving state and Federal conservation and law enforcement authorities from Maine to Texas. The network compiles reports of dead or weakened turtles found on beaches or at sea. These reports are stored in a computer at the Center where they are available to researchers.

NMFS Scientists Improve Productivity with New Analytical Method

A new and improved method of chemical analysis for organic contaminants has been developed by scientists of the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS). The new method will enhance agency efforts to monitor the quality of the marine environment while maintaining analytical precision and reducing time and costs by as much as two-thirds.

The breakthrough came from research by Margaret Krahn and Donald Brown working with their associates under the direction of William MacLeod, Jr. and Sim-Lam-Chan in the Environmental Conservation Division of the NMFS Northwest Fisheries Center located in Seattle, Washington.

Usha Varanasi, Director of the Environmental Conservation Division, said "NOAA scientists have made a valuable contribution to environmental science and management." She added, "Even more savings will be realized when other agencies and groups, both public and private, successfully implement the method."

The new method separates organic molecules according to their sizes and shapes. This is accomplished during the isolation or "clean up" phase of the process involving high-pressure liquid chromatography. The new method is more precise because fewer steps are necessary and most of the steps have been automated. Further, the new method requires less time to complete, provides a capability to monitor the chromatographic conditions, and reduces the amount of highly pure solvent needed.

The development of the new method was partially funded by other NOAA offices particularly the National Status and Trends Program and the Outer Continental Shelf Environmental Assessment Program of the Office of Oceanography and Marine Assessment. This improved method promises substantial savings to NOAA programs. When fully implemented the annual savings to NOAA could amount to a million dollars or more, which would allow a much more comprehensive and definitive approach to monitoring the status of the environment.

New Ocean Venting Field Found in Eastern Pacific

A spectacular field of underwater hot springs, minerals, and exotic animal life at least five city blocks long has been discovered on an underwater volcanic mountain range 100 miles off the Oregon coast, the National Oceanic and Atmospheric Administration (NOAA) has announced. A team of government and academic scientists made the discovery in late October 1988 during a series of dives on the Gorda Ridge, using a U.S. Navy deep submergence vehicle, the DSV *Sea Cliff*, according to Peter Rona the team's chief scientist.

The significance of the discovery, the Commerce Department scientist said, is that the United States now has within its Exclusive Economic Zone "a natural setting providing scientists a new frontier for scientific investigation to study first-hand how seafloor hot springs form metallic mineral deposits, support exotic forms of life, and influence the ocean environment." Rona said, large plates of the earth's crust are pulling apart, allowing seawater to seep through cracks and come in contact with hot volcanic rocks in the area of the find. The heated water leaches metals from the rocks, then rises and deposits the metallic minerals on the sea floor.

Diving to depths of 10,000 feet on the eastern wall of a valley in the submerged volcanic mountain range, the scientists observed diffuse flows of low-temperature fluids seeping up through the sea floor, as well as geyser-like flows of high temperature fluids spewing through chimney-like structures up to 10 feet high. The temperature of the water in one of the hot springs was recorded at nearly 500°F, Rona said. Within the field of hot springs, toppled chimneys resembling fallen logs are strewn about the seafloor. Thickets of tube worms several feet high, topped with bright red plumes, are growing around the springs, and scientists saw crabs, octopi, deep-sea fish, and other animals.

The discovery was made as the party was carrying out geological and biological investigations of the northern Gorda Ridge. The expedition was coordinated by the Gorda Ridge Technical Task Force, a joint Federal-state working group established in 1984 by the secretary of the Department of the Interior and the governors of Oregon and California. Members of the dive team were from NOAA, the U.S. Geological Survey, Oregon State University, the Oregon Department of Geology and Mineral Industries, and the Universities of California (Davis) and Hawaii.

Recognizing the navy's contribution to the study by making the DSV *Sea Cliff* and its support vessel, the DSVSS *Laney Chouest*, available, the scientific team has designated the area—situated high above cliffs on the wall of a valley—as the Sea Cliff Hydrothermal Field.

Science, Agencies Tell Arctic Ozone Studies

Two Federal science agencies, the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA), announced in December 1988 a cooperative investigation to

understand better the nature of potential depletion of stratospheric ozone over the Arctic. During January and February 1989, scores of scientists from the two agencies and nearly a dozen other research organizations will carry out an airborne study similar to that done last year on Antarctic ozone depletion. That study directly implicated manmade chlorofluorocarbons (CFC's) as a cause of the "ozone hole" over Antarctica in the austral spring, and raised the question whether a similar phenomenon could be occurring in the Arctic, perhaps on a reduced scale.

Earlier in 1988, in smaller, separate field investigations, NOAA and NASA found elevated levels of chlorine compounds in the atmosphere over the Arctic, giving urgency to the forthcoming joint study. NASA Headquarters has organized the expedition and is providing overall mission management and support through its Upper Atmosphere Research Program, while NOAA's Aeronomy Laboratory is providing project science management, according to NASA's Robert Watson, the chief program manager.

Daniel L. Albritton, director of NOAA's Aeronomy Laboratory, Boulder, Colo., said the investigation will search for ozone-depletion processes within the Arctic vortex and their possible influence on ozone concentrations over heavily populated northern mid-latitudes. "If even a small fraction of the Antarctic loss is occurring in the Arctic," he said, "it would more than double the predicted high-latitude ozone depletion." The planned Airborne Arctic Stratospheric Expedition will fly specially instrumented NASA ER-2 and DC-8 aircraft into the Arctic vortex from 1 January through 15 February 1989. The timing of the flights coincides with the statistically most active period for the formation of extremely low-temperature polar stratospheric clouds there. Such clouds are involved in the complex processes that result in the destruction of stratospheric ozone in the Antarctic polar vortex. Aircraft operations and management are being provided by NASA Ames Research Center, Moffett Field, Calif.

NE Fishing Vessel Catches Are Sampled

The Northeast Fisheries Center of the National Marine Fisheries Service's Northeast Region has awarded a contract to the Manomet Bird Observatory of Manomet, Mass., to conduct an experimental program of sea sampling. Under the contract, Manomet Bird Observatory will place biological technicians (sea samplers) aboard U.S. commercial fishing vessels in the Northeast to sample vessel catches and collect detailed information on vessel operations. The contract calls for sea sampling of about 200 commercial fishing trips between 1 January and 30 September 1989, covering six major Northeast fisheries.

Fisheries to be sampled are the small-mesh and shrimp fisheries in the Gulf of Maine, the large-mesh and experimental silver hake (whiting) fisheries on Georges Bank, the Nantucket Shoals trawl fishery, and the winter trawl fishery offshore of the Mid-Atlantic Bight and Chesapeake Bay.

According to Allen E. Peterson, Jr., Science and Research Director of the NMFS Northeast Region, the purpose of the program is to provide fisheries scientists, economists, managers, and administrators with "detailed tow-by-tow information for better characterizing fishing operations, fishermen's catches, and fish populations off the Northeast coast." Peterson adds that such information is "essential for improving fisheries management in a manner which both conserves our renewable fisheries resources and addresses the economic interests of commercial fishermen."

Fishing Vessel Seized for Unpaid Penalties

The F/V *Explorer*, a fishing vessel out of Key West, Fla., was arrested on 14 November 1988, by the U.S. Marshal, with assistance from a National Marine Fisheries Service Special Agent, officers of the Florida Marine Patrol, and a U.S. Customs Service Agent, pursuant to an arrest warrant issued by the U.S. District Court in Miami, according to John L. Pedrick, Jr., Southeast Regional Counsel for the National Oceanic and Atmospheric Administration. The vessel was arrested to satisfy a maritime lien in the amount of $82,864.50, plus accrued interest and penalties, for unpaid civil penalties assessed against the owner and operator of the *Explorer* for violations of the Magnuson Fishery Conservation and Management Act. If the penalties remain unpaid, the vessel will be sold under court order to satisfy the Government's claim. This is the first of the vessels to be arrested to satisfy unpaid Magnuson Act penalties owed to the Government.

Japan's "Fugu" or Puffer Fish Market

Japan imported nearly 1,700 metric tons (t) of fugu (commonly known as blowfish, globefish, puffer, or swellfish), valued at $9.7 million in 1987. Japanese imports of fugu have increased more than 140 percent since 1985.

The fugu (puffer) gets its name from its ability to expand its body by two to three times normal size when it becomes agitated or frightened, thus taking on a balloon shape. It does this by gulping air or water into a sac in its belly. This behavior serves to frighten away predators or intimidate rivals.

Background

Although fugu is one of the world's most poisonous fish, the Japanese have consumed it for centuries. The fugu's skin, ovaries, intestines, and liver contain tetrodotoxin, a powerful neurotoxin. If even a trace of these organs is left on the flesh of the fish, the consumer can die within minutes. A lethal dose of tetrodotoxin is about 1 mg and there is no known antidote. In Japan, about 60 percent of all fugu poisonings are fatal.

From 1974 to 1984, Japan had about 20 fugu poisoning fatalities per year. The trick to surviving a fugu meal is to make sure that it is prepared correctly—all traces of the internal organs must be removed from the fish's flesh. (To be completely fair to the fugu, it should be noted that fugu do vary widely in toxicity and some species are nontoxic.) The taste of fugu is said to be similar to chicken.

Domestic harvest

There are more than 100 species of fugu worldwide and nearly 25 percent of these are caught in the Sea of Japan, Yellow Sea, and East China Sea (Table 1). Two of the most important species harvested by Japanese fishermen are torafugu, *Fugu rubripes rubripes*, and karasu, *Fugu rubripes chinensis*.

Japanese domestic landings of torafugu and karasu range from 2,000 to 2,500 t a year. Both species are caught by longliners from September through March in the southwestern Sea of Japan and from July through January in the Seto Inland Sea. In November 1986, the Japan Tsushima Swellfish Longline Fishery Company of Tsushima, Nagasaki Prefecture, signed a 3-year private agreement with the North Korean Government to fish for fugu in the Yellow Sea off the west coast of North Korea. Because the North Koreans do not allow fugu longlining, the Japanese use only pole-and-line fishing methods. Japan has historically fished for fugu in North Korean waters because of the large size and high quality of the fish caught there. Fugu caught in waters off South Korea are said to be of lower quality.

From 300 to 800 t of pen-raised fugu are harvested annually from October through December in Yamaguchi Prefecture. Most of these are

Table 1.—Species of fugu (puffer fish) imported by Japan.

Japanese name and scientific name
Ishigakifugu, *Chilomycterus affinis* Gunther
Harisenbon, *Diodon holacanthus* Linne
Nezumifugu, *Diodon hystrix* Linnaeus
Hitozura-Harisenbon, *Diodon liturosus* Shaw
Akamefugu, *Fugu chrysops*
Sansaifugu, *Fugu flavidus*
Kusafugu, *Fugu niphobles*
Mefugu, *Fugu ocellatus*
Higanfugu, *Fugu pardale*
Komonfugu, *Fugu poecilonotum*
Karasu, *Fugu rubripes chinensis*
Torafugu, *Fugu rubripes rubripes*
Gomafugu, *Fugu strictonotum*
Mafugu, *Fugu vermiculare porphyreum*
Shosaifugu, *Fugu vermiculare vermiculare*
Shimafugu, *Fugu xanthopterum*
Kurosabafugu, *Lagocephalus gloveri*
Kanafugu, *Lagocephalus laevigatus inermis*
Sabafugu, *Lagocephalus lunaris lunaris*
Shirosabafugu, *Lagocephalus wheeleri*
Yoritofugu, *Liosaccus cutaneus* Gunther
Hakofugu, *Ostracioncubicus linnaeus*
Nashifugu, *Takifugu radiatus*

Table 2.—Japanese imports of fugu (fresh, chilled, and frozen), by country and quantity, 1980-87.

	Imports (t)							
Country	1980	1981	1982	1983	1984	1985	1986	1987
Taiwan		24	15				50	755
South Korea	798	518	332	302	381	513	806	682
China	25	114	154	186	209	149	148	199
North Korea	27	14	32	15	37	31	36	22
Total	850	670	533	503	627	693	1,040	1,658

Table 3.—Japanese imports of fresh, chilled, and frozen fugu, by country and value, 1980-87.

	Imports (US$1,000)							
Country	1980	1981	1982	1983	1984	1985	1986	1987
South Korea	5,825	4,203	2,365	2,426	3,220	2,797	6,530	7,997
China	75	666	1,081	1,203	1,382	1,178	1,190	921
Taiwan		59	15				43	661
North Korea	113	49	98	35	137	96	191	219
Total	6,013	4,978	3,559	3,664	4,739	4,071	7,954	9,797

Table 4.—Japanese imports of fresh torafugu, *Fugu rubripes rubripes*, by country, quantity, and average value per kilogram, 1980-86. All values on this table are C.I.F. yen/kg.

			South Korea		North Korea		China	
Year	Total Imports (t)	Average Value (¥/kg)	Amt. (t)	Value (¥/kg)	Amt. (t)	Value (¥/kg)	Amt. (t)	Value (¥/kg)
1980	204	2,648	204	2,648				
1981	193	2,773	188	2,778			5	2,599
1982	108	2,795	87	2,856			21	2,548
1983	77	3,112	77	3,112				
1984	121	3,499	118	3,565	4	1,313		
1985	138	2,842	126	2,919	6	4,861	6	2,208
1986	346	2,431	334	2,469	6	1,298	6	1,470

Table 5.—Monthly changes in Japan's import quantity and average value of fresh torafugu, *Fugu rubripes rubripes*, by country, 1985-86, and January-August 1987. All values are C.I.F. ¥/kg.

			Quantity (t)		
Year/ Month	Total Amt. (t)	Avg. value (¥/kg)	S. Korea	N. Korea	China
1985					
Jan.	24	3,187	24		
Feb.	5	2,622	5		
March	4	2,288	4		
April		2,312			
May	1	2,180	1		
June					
July					
Aug.	1	1,426	1		
Sept.	2	1,723	1		
Oct.	14	1,957	9		5
Nov.	33	2,179	28	3	2
Dec.	54	3,499	51	3	
1986					
Jan.	31	2,302	31		
Feb.	54	1,022	54		
March	46	948	46		
April	2	1,878	2		
May	1	1,231	1		
June	2	1,332	2		
July	1	1,576	1		
Aug.	1	1,905	1		
Sept.	9	1,863	9		
Oct.	55	2,515	53	1	1
Nov.	81	2,832	71	5	4
Dec.	65	4,315	64	1	
1987					
Jan.	75	3,046	75		
Feb.	53	2,191	53		
March	17	2,691	17		
April	1	1,566	1		
May	7	1,550	7		
June	4	1,513	4		
July	3	2,027	3		
Aug.	7	2,057	7		

Table 6.—Japanese imports of frozen fugu, by country, quantity, and average value per kilogram, 1980-86. All values are C.I.F. ¥/kg.

			S. Korea		N. Korea		China		Taiwan	
Year	Total imports (t)	Avg. value (¥/kg)	Amt. (t)	Value (¥/kg)	Amt. (t)	Value (¥/kg)	Amt. (t)	Value (¥/kg)	Amt. (t)	Value (¥/kg)
1980	646	1,291	594	1,331	27	978	24	687		
1981	477	1,158	330	1,188	14	748	109	1,252	24	561
1982	426	1,381	246	1,399	32	762	133	1,625	15	254
1983	426	1,466	225	1,484	15	547	186	1,519		
1984	506	1,385	263	1,283	34	818	209	1,606		
1985	555	936	387	702	25	386	143	1,664		
1986	694	733	472	597	30	757	142	1,388	50	148

Table 7.—Monthly changes in Japan's import quantity and average value of frozen fugu, by country, 1985-86, and January-August 1987. All values are C.I.F. ¥/kg.

			Quantity (t)			
Year/ Month	Total Quantity	Average Value	South Korea	North Korea	China	Taiwan
1985						
Jan.	25	1,146	11		14	
Feb.	94	740	89		5	
March	84	600	79		5	
April	90	513	90	1		
May	30	584	25		5	
June	12	401	12			
July	26	2,335	26			
Aug.						
Sept.	9	1,018	9			
Oct.	30	1,307	13		17	
Nov.	23	487	5	18		
Dec.	132	1,385	29	6	96	
1986						
Jan.	104	1,051	72		32	
Feb.	127	655	120		7	
March	99	443	85	1		14
April	94	457	76	8	10	
May	45	410	27			
June	40	362	19	1	2	18
July	7	501	3	3	1	
Aug.	30	918	6	7	17	
Sept.	5	1,080	1	3	2	
Oct.	24	801	21		21	
Nov.	27	885	23		4	
Dec.	92	1,275	19	8	64	
1987						
Jan.	143	715	5		58	80
Feb.	44	431	19		25	
March	45	442	25			20
April	22	346	11			10
May	16	659	16			
June	250	400	86		2	162
July	107	312	19			89
Aug.	31	179	7			23

sold fresh or live at auction in Karatsu (Yamaguchi Prefecture), and shipped to major cities, such as Osaka and Tokyo.

Imports and Markets

Japan allows 22 fugu species to be imported (Table 1). Annual fugu imports averaged about 650 t from 1980 to 1985, valued at $4.5 million (Tables 2, 3). The figu's increasing popularity in recent years among younger Japanese consumers pushed imports to a 1987 record high of 1,700 t, valued at nearly $9.8 million. Taiwan was the major exporting country by quantity in 1987, shipping over 750 t, 15 times the quantity exported in 1986. South Korea was a close second with exports of 680 t, but was the hands-down winner by value—nearly $8 million. China and North Korea also exported fugu to Japan in 1987. Fresh torafugu is the major species imported from South Korea, China, and North Korea (Tables 4, 5). Frozen sabafugu, *Lagocephalus lunaris lunaris*, and kusafugu, *Fugu niphobles*, are also imported from these countries, as well as Taiwan (Tables 6, 7).

Fresh (or live) and frozen fugu are marketed differently in Japan. Both torafugu and karasu are normally marketed fresh or live at weights of 1.5-2.0 kg per fish. These two species are highly valued, selling for 3,090-4,700 ¥/kg (about $23-$35/kg at ¥133/US$1) at Tokyo's Tsukiji Fish Market (Table 8). They are usually served as sashimi (very thin slices of raw fish) at expensive restaurants. Often fugu sashimi will be arranged in patterns resembling flowers or birds.

Frozen sabafugu and kusafugu are utilized primarily for processing and stewing, although some may be consumed as sashimi. They are usually imported frozen in 10 kg blocks and sold directly to the processors, bypassing Japan's wholesale auction markets. Two typical fugu processed products are fugu "ichiyaboshi" (semidried whole fish) and dried fugu or "fugu rolls" (headed fugu butterfly fillets pressed between rollers and dried).

Because the fugu's skin and viscera are extremely toxic, 14 prefectures, including Tokyo, allow only certified chefs to prepare fugu. All fugu cooks must take intensive courses, apprentice at least 2 years, and pass written exams. There are some 30 steps prescribed by law for preparing fugu.

Table 8.—Live and fresh fugu sales at Tsukiji Market, Tokyo, Japan; by quantity and average price per kilogram in yen, 1980-86.

Year	Quant. (t)	Yen per kilogram
1980	484	3,299
1981	553	3,364
1982	452	3,528
1983	556	3,748
1984	644	3,513
1985	709	4,024
1986	895	4,694

Import Regulations

Because of the obvious health risks involved with the consumption of fugu, the Japanese Ministry of Health and Welfare rigidly controls imports of fugu into Japan. Fugu may be imported either unprocessed or gutted (as long as the identification of each fish is not impaired). Fish must be tagged with an official certificate from the exporting country identifying it by scientific name, fishing ground, and attesting to the fact that it received proper sanitary handling. If the fish is frozen, it must have been deep frozen and stored at a temperature below −10°C. In addition, each fish should be individually frozen for easy identification. If this is not possible, fish may be frozen in blocks, but each fish's back and belly must be visible for species identification. If official certificates are incomplete or detached, or if the cargo is mixed with other species restricted from import, the cargo may be returned to the exporter. Imports of the same or other fugu species harvested in other waters must be negotiated with the Japanese Government to determine certificates of toxicity, fishing ground, species, etc. Import duties are 10 percent of the C.I.F. value for fresh, frozen or fillet.

U.S. Puffers

A number of puffers are caught in North American waters. One of the most common is the northern puffer, *Sphoeroides maculatus*, a nontoxic species which was popularly marketed as "sea squab" along the Atlantic Coast during World War II. Unfortunately, the northern puffer is not on Japan's current import list and consequently cannot be imported into Japan. Ministry of Health and Welfare officials have indicated that negotiations for market access might be possible. Although the Japanese are not familiar with northern puffer, it could find a market if it is of sufficiently high quality. (Source: IFR-88/80.)

Soviet Fish Catch off Latin America

The Soviet distant-water fleet caught a record 1.0 million metric tons (t) of fish off Latin America during 1987, surpassing the previous record (0.8 million t, set in 1986) by over 20 percent. Latin American grounds are some of the few grounds in which the Soviets have reported significant catch increases in recent years.

Almost 10 percent of the total Soviet fisheries catch was taken off Latin America in 1987. Much of the 1987 increase was a result of higher catches in the eastern Pacific outside the 200-mile zones of Peru and Chile, where about 85 percent of the 1987 catch (over 0.8 million t) was taken. Most of this catch was Chilean jack mackerel. The remainder of the Soviet catch off Latin America, totalling nearly 0.2 million t, was taken in the Southwest Atlantic, mostly in Argentine waters.

Reflecting the growing importance of Latin American grounds, the Soviet Union seeks access to fishing grounds off several Latin American countries. The Soviets are particularly interested in access to Argentine and Peruvian grounds. The Soviet Union began operating in Argentine waters during May 1987, under the auspices of a bilateral fishing agreement that allows the Soviets to catch almost 0.2 million t of fish annually. Most of the Soviet catch in the southwest Atlantic was squid, southern blue whiting, and grenadier. The Argentine-Soviet agreement was renewed in October 1988. Soviet efforts to sign agreements with Peru and Uruquay have been stymied by strident local political opposition and demands by the Latin Americans for a large share of the Soviet catch. Nevertheless, Peru reportedly signed a bilateral agreement with the Soviets in early December 1988.

Canada's Atlantic Aquaculture Industry

Atlantic salmon was Canada's most valuable species of farmed fish, with production worth C$14 million in 1987, close to the value of Atlantic Canada's herring or haddock fisheries. Mussel farming was worth C$3 million and it continues to grow despite an incident involving toxin in late 1987. Production of cultivated trout, European oysters, bay scallops, sea scallops, and other species is expanding and shows promise for significant expansion in the future. By 1995, Canadian fish farmers might be able to produce 45,000 t of fish and shellfish worth over $225 million.

Role of Government

The Canadian Government's Department of Fisheries and Oceans (DFO) plays an active role in Atlantic Canada's aquaculture industry. A key responsibility includes enacting and enforcing regulations. The expanding use of sheltered bays and inlets for fish farming created a need for regulations to avoid conflicts with commercial fishermen, navigators, recreational boaters, and others. The DFO is particularly concerned that marine farming and traditional fisheries coexist, and it works with other Federal ministries, provincial governments, and local municipalities to support and manage the orderly development of aquaculture.

Despite impressive growth in recent years, aquaculture is still a new industry which is rapidly developing. The need for scientific research remains critical. The intricate process of growing wild creatures in captivity requires constant effort to improve growing techniques and broodstock, control diseases, improve nutrition, and to deal with unforeseen problems—anything from a mysterious poisoning to the unexpected effects of a very cold winter. The DFO is assisting the industry by sponsoring research in all of these areas.

One of DFO's main aquaculture activities is preserving the health of fish stocks. The DFO Fish Health Unit, located at the Halifax Laboratory, enforces Federal Health Protection Regulations for both the Scotia-Fundy and Gulf Regions. Its job is to test fish for disease. All salmon, for example, going from hatcheries to cages have to be tested for enteric redmouth disease, furunculosis, and bacterial kidney disease (BRD), the latter being a particular concern because it's believed to be transferrable through the egg. Fish crossing international boundaries, provincial boundaries, or even being transferred from one water system to another must be tested. The regulations are stringent because most outbreaks of fish disease occur when fish are transferred from one site to another without proper controls.

The Fish Health Unit certifies both hatcheries and fish farms. Private groups and individual growers are building an increasing number of hatcheries in the Scotia-Fundy region, adding to the half dozen Federal salmon hatcheries which stock rivers and supply marine farmers with salmon smolts. The Unit investigates fish kills, checks for chemical and other environmental hazards, and monitors the approach of paralytic shellfish poisoning. This practical program is complemented by a group conducting research into fish disease such as furunculosis and BKD. At the Halifax Laboratory a team of scientists is exploring the different strains of these diseases and how and why they kill fish—essential information before they can be controlled or eradicated.

Aquaculture Programs

The center of Atlantic Canada's salmon culture industry is the Scotia-Fundy region. Conditions there are ideal for salmon farming; the flushing action of the tides, the upwelling of nutrients, suitable water temperatures, and protected sites have helped this region to become one of the best salmon growing areas in the world. Canadian production of farmed Atlantic salmon, *Salmo salar*, totaled 2,800 t in 1987, and officials believe farmed salmon production will reach 27,000 t by 1990, making Canada the third largest producer of farmed salmon in the world.

Responding to the need for information on aquaculture by new entrants to the industry, the DFO opened the Salmonid Demonstration and Development Farm (SDDF) at Lime Kiln Bay in 1986. The SDDF provides commercial fish farmers with scientific and technical information about culturing salmon in cages and demonstrates how a salmon farm works. It also conducts research and develops improved grow-

Mexico Gets New Fisheries Minister

Mexican President Carlos Salinas de Gortari announced his new cabinet on 30 November 1988. His new Fisheries Minister is María de los Angeles Moreno Uriegas. Moreno was an Under Secretary under Salinas at the Secretariat of Programming and Budget and directed the President-elect's Committee on Fisheries Planning. She has also served on the Board of Directors of the government-owned fisheries export marketing company. She is reputed to be an expert on the international trade in seafood products.

ing techniques. The farm receives financial contributions under terms of a Canada-New Brunswick Economic Resource Development Agreement. It is managed through the St. Andrews Biological Station, but is run as a working farm by a private company under contract. Scientists with expertise in salmon biology and culture, genetics, fish disease, nutrition, and marine engineering direct the SDDF's work along with an advisory committee composed of federal, provincial, and private sector representatives who ensure that the research is relevant to the needs of the industry.

The main emphasis of the SDDF research is nutrition. Various diets are tested, especially moist vs. dry formulations. Combinations of different feed mixtures at various stages of the salmon's complex growth are also examined. Testing includes different vitamin and mineral supplements. Presently, the nutritional analysis is done at the Halifax Laboratory of the DFO, but a nutrition laboratory is scheduled to open soon. Learning the physiology and biology of fish (how they work and how they grow) is another priority. In some experiments smolts have been manipulated to see if periods in salt water affect their "growout." One potentially useful discovery is that artificially extending daylight hours (especially between August and November) makes salmon grow faster. Other programs are designed to improve management techniques, evaluate sea cage systems, and to upgrade stock.

Associated with the SDDF is the Salmon Genetics Research Program (SGRP) jointly sponsored by the DFO and the Atlantic Salmon Federation, a private nonprofit conservation group. Scientists are trying to develop fish with improved disease resistance. They are also working to delay sexual maturation so that the fish keep growing instead of diverting energy for breeding.

Genetic research for characteristics suitable for better domesticated stock is only part of the SGRP's program. Scientists at the Atlantic Salmon Federation's research facilities near St. Andrews, are also working on "searanching," releasing smolts into the ocean in the expectation that they'll return to their place of birth as mature adults where they can be harvested. Unfortunately, less than 3 percent of these smolts return as mature adults (in Iceland, 20 percent return to spawn in their native rivers). In some rivers, however, there's a higher and earlier return rate suggesting that the salmon don't migrate as far in the ocean; it is possible that these fish might form the stock for sea ranching.

At the DFO Biological Station in St. Andrews, scientists are conducting an interesting experiment in which they are hoping to extend the "time window" when smolts can be released into salt water. This is normally only a couple of weeks in spring when the physiology of the year-and-a-half old salmon changes—their dark stripes become silver and they prepare to swim downstream. However, they die if they reach salt water too early or too late. A million smolts go into the ocean at that time, and it's a hectic period which taxes both hatchery and laboratory facilities since all the batches have to be tested for disease and transported within a very limited time frame.

Meanwhile, commercial salmon sea cage operations are being monitored by DFO scientists for possible pollution problems, especially from aquaculture facilities themselves (uneaten feed, chemicals, and fish waste). Most of the salmon growers in Atlantic Canada are concentrated in L'Etang estuary near St. George, where most of the 34 New Brunswick sites are located (there are six more in Nova Scotia). L'Etang is ideal because it combines shelter from the open sea with warmer winter temperatures—a rare combination on the Atlantic

Argentine Fisheries Developments Noted

Argentine fishermen caught 550,000 metric tons (t) of fish in 1987, an increase of 30 percent over the 411,000 t caught in 1986. Argentina exported 241,200 t of fishery products during 1987, valued at a record US$267 million. Most of the Argentine shipments were hake and squid. The primary reason for the expanded shipments was increased demand for demersal finfish in the European Community (EC) and the United States, and increased purchases by Australia and communist countries. Substantially higher squid catches, accompanied by strong demand for squid in the EC was also an important factor.

The Argentine fishing industry is highly dependent on export markets despite efforts to increase domestic consumption. The Argentine Government has bilateral agreements with the Soviet Union and Bulgaria, which permitted a limited number of fishing vessels from those countries to operate in Argentine waters during 1987. The Government has been unsuccessful in its efforts to negotiate similar agreements with Spain, Japan, and other countries.

The U.S. Embassy in Buenos Aires has prepared a 24-page report summarizing recent fishery developments in Argentina. The report has information on catch, exports, bilateral fishery relations, foreign investment, and government involvement in and policy toward the fishing sector. The report also includes detailed statistical appendices on catch and exports. U.S. companies can obtain a copy of "1987 Report on the Argentine Fishing Industry" for $13.95 and a $3.00 handling fee (total $16.95, personal checks or money orders only) by ordering report PB89-127880/GBA from NTIS, 5285 Port Royal Road, Springfield, Virginia 22161. (Source: IFR-88/109N.)

Coast. But scientists are concerned that wastes from the cage operations will create algal blooms that might adversely affect salmon growth or other marine life, especially if aquaculture facilities in the L'Etang estuary continue to expand and the area becomes more congested. Tests show that this is not happening yet, but nutrient and oxygen levels in the water are being carefully monitored.

Trout farming is the oldest aquaculture sector in Atlantic Canada. Total trout production in 1986 was about 2,400 t worth C$16 million. Rainbow trout, *Oncorhynchus mykiss*, and brook trout, *Salvelinus fontinalis* are both raised commercially, frequently in conjunction with salmon farming: About a third of salmon farmers also raise trout. There are a few large operations growing only trout, the largest being in Bras D'Or Lake in Cape Breton. But hundreds of freshwater operations have sprouted throughout the Maritimes, many for angling purposes. Trout reach "pan size" easily, but bringing them up to large sizes takes more sophisticated knowledge. Nutritional analysis and feed development have been done for trout as for salmon, and the same disease precautions are taken. Atlantic Canada's largest trout farm was opened in Prince Edward Island (PEI) in the summer of 1988. The farm, a joint venture between Norwegian and Canadian investors, plans to market about 400 t of rainbow trout annually (about 200,000 fish).

The most widely cultured shellfish species in the Scotia-Fundy Region is the blue mussel, *Mytilus edulis*, grown by about 100 marine farmers along the coast in sheltered bays. In 1987, the Canadian production of blue mussel was valued at C$1.5 million. About half of these blue mussels were raised around Prince Edward Island. This industry has expanded at a hectic pace. The mussels grow quickly in the cold northern waters which are their natural habitat, and seed is easily collected in the wild, as opposed to other cultured mollusks which require hatcheries. When cultivated mussels were first introduced to the market they were sold for the same price as wild mussels. When consumers realized that farmed mussels have more meat than their wild counterparts, the price for cultivated mussels doubled.

Provincial and Federal governments have helped with financing, technology, and other practical matters. Since mussels require only an artificial structure to grow, little research into genetics or nutrition is needed. The sudden and unforeseen toxic poisoning that hit Prince Edward Island mussels in late 1987, resulted in one of the most intense scientific efforts Canada has ever seen to identify the toxin (domic acid) causing the problem. The effort by Federal and provincial authorities underscores the importance of research in marine farming, especially of shellfish, for health protection. Blue mussel production in the late 1970's was about 10 t, but by 1986, Nova Scotians produced 1,400 tons.

High quality mussels are produced using mainly the longline systems of suspended culture. The mussel industry is composed of two general types of operation: Those producing significant commercial quantities of mussels and those growing less than 15 t annually. Collection of seed mussels for sale to growers is a new activity that is growing quickly. The mussel farming industry faces several constraints in the future which will require research and monitoring. These constraints include the capacity of estuaries to support mussel culture, the impact of mussels on the ecology of the estuary, the spread of paralytic and diarrehetic shellfish toxins, and the quality of the waters.

American oysters, *Crassostrea gigas*, are being grown successfully at sites along the coast of Nova Scotia. In 1986, harvests of oysters exceeded 3,000 t in Atlantic Canada. Canadian oyster farmers also harvested a small quantity of European oyster, *Ostrea edulis*. The European oysters were introduced in the late 1960's by DFO personnel, who nurtured them to the commercial stage. They grow well and the market is good, but expansion has been slow because of the shortage of hatchery capacity, a problem that should be gradually overcome as new private hatcheries add to the government and university facilities that served the industry in its infancy.

Early experiments with the native oyster in the Bras D'Or !ake were biological successes, but were not commercial successes. Native oyster culture operations are concentrated in the Gulf Region. Because oysters hibernate in the winter, they can be harvested in the late fall and put in cold storage to force hibernation and kept for up to 3 months. Exporters can then take advantage of the high prices available in the European market during the winter holidays.

Some aquaculturists believe that the bay scallop will be Canada's next success story. The bay scallop, a small scallop introduced from the U.S. Atlantic coast, has been grown experimentally at selected sites in Nova Scotia with good results. One of its advantages is that it grows to maturity in a year. It's main disadvantage is that it does not tolerate harsh winter conditions. Bay scallops provide a far smaller meat than the sea scallop, but it is prized by the Japanese. Meanwhile, the Halifax Laboratory, which is equipped with a quarantine unit (all live fish coming into the country must be quarantined), is hoping to bring in new stock to expand the genetic base of both the bay scallop and the European oyster. Atlantic farming of bay scallops began with only a small number of individuals and would likely benefit from expanded broodstock and improved genetic diversity.

Sea scallops are also being evaluated for aquaculture. Scientists at St. Andrews are testing various kinds of suspension cages at Lime Kiln Bay

Table 1.—Aquaculture production in Atlantic Canada, by quantity, 1984-86.

Species	Production (t) 1984	1985	1986
Atlantic salmon	222	349	655
Blue mussel	876	909	1,845
Rainbow, brook trout	NA[1]	NA	947
American oyster	NA	NA	2,400[2]
European oyster	NA	NA	5

[1]Not available.
[2]Includes both wild and cultured species.

near the SDDF, and are trying to learn if there's enough spatfall in Passamoquoddy Bay and the Bay of Fundy that could be gathered in the wild to support a scallop aquaculture industry. If not, development of this industry would be dependent upon hatchery production.

Lobstering is big business in Canada. In 1987, Canadian fishermen caught 35,400 t of lobster valued at C$264 million. Any program that can enhance natural stocks or raise lobsters in captivity is of significant interest to Atlantic Canada. A long-term pilot project at the St. Andrews Biological Station has shown that lobster can be grown and reproduced in captivity. The economics are difficult and attempts to grow them commercially have not yet been successful. Nevertheless, this research has had positive results. For example, researchers discovered that lobsters kept at cold temperatures will not molt or spawn, are resistant to disease, maintain their meat quality for a long period, and don't need feeding. This has provided the scientific basis for land-based lobster pounds which allow Canada to supply high quality lobster to international markets throughout the year. There is also continuing work underway by private lobster companies in cooperation with DFO to grow "canner" lobsters to market size.

A small number of halibut are being grown at the St. Andrews Biological Station and in a sardine weir on New Brunswick's Fundy Coast. Preliminary testing has shown halibut take well to confinement. They're considered a good candidate for aquaculture because of their high value and because, like salmon, the whole fish is purchased by the consumer, not just a filet. Larval studies are underway to see if species like striped bass, haddock, halibut, eels, and other marine fishes can be reproduced from the egg in captivity. This work is more basic than applied research and may not prove relevant to marine farming for some time.

Conclusion

Aquaculture in Atlantic Canada is a rapidly growing industry, with production growing steadily in recent years. The immense interest in aquaculture has lead the DFO and provincial governments to develop joint programs and legislation ensuring the safe and orderly development of the industry. Atlantic Canada has benefitted greatly from aquaculture through increased employment and exports and these benefits should continue to increase as the industry expands. By 1990, Atlantic Canada might be the world's third largest producer of farmed fish and shellfish if production goals are achieved.
(Source: IFR-88/94.)

Chilean Fisheries Growing Rapidly

The Chilean fishing industry has been the fastest growing sector in the Chilean economy during the past 11 years, growing at an average annual rate of 10 percent. In 1987, however, the industry experienced its first decline in recent years. Fishery landings totaled 4.9 million metric tons (t) in 1987, a 13 percent decline from 1986 levels. Fishermen reported record jack mackerel landings in 1987, which were 50 percent higher than 1986 landings. The overall decline in landings was caused by a sharp decline in anchovy landings, which plummeted from 1.5 million t in 1986 to only 0.3 million t in 1987. Almost 90 percent of all 1987 landings were reduced into fishmeal and fish oil.

Despite the declining catches, however, export earnings actually increased in 1987. Fisheries accounted for 13 percent of Chilean exports in 1987, earning $638 million (up 23 percent from 1986). The increase in export earnings was mainly due to a rise in the world price of fishmeal during 1987. The Undersecretariat of Fisheries tightened pelagic and shellfish management measures because of concern about overfishing (especially of sardine and anchovy stocks) and worked on developing a new fisheries law. Announced investments in the fishing industry totaled about $100 million, with over 40 percent going to the growing salmon culture and processing industry.

The U.S. Embassy in Santiago has prepared a 41-page report summarizing recent fishery developments in Chile. The report has information on landings, fleet, development programs, new investment projects, ports, aquaculture, industry developments, markets, government policies, and research. The report includes a list of government institutions and private companies and detailed statistical appendices on landings, processing, and trade. U.S. companies can obtain a copy of "Chile: Industrial Outlook Report, Fishing Industry 1987" for $13.95 and a $3.00 handling fee (total $16.95, personal checks or money orders only) by ordering report PB89-122311/GBA from NTIS, 5285 Port Royal Rd., Springfield, Virginia 22161. (Source: IFR-88/106N.)

Fish Disease Diagnosis and Basic Fishery Computer Programs

The second edition of **"Disease Diagnosis and Control in North American Marine Aquaculture,"** edited by Carl J. Sindermann and Donald V. Lightner, has been published by Elsevier Science Publishers, P.O. Box 330, 1000 AH Amsterdam, The Netherlands, as volume 17 in their series "Developments in Aquaculture and Fisheries Science." Sindermann is with the NMFS Northeast Fisheries Center, Woods Hole, Mass., and the University of Miami, Fla., and Lightner is with the University of Arizona's Environmental Research Laboratory in Tucson.

The control of diseases depends on correct diagnosis, proper preventive measures, and proper treatment, and this vastly updated second edition should be a big help to aquaculturists and others involved in the detection, prevention, and treatment of fish diseases. It includes excellent summaries of current information on the diseases of cultivated marine fishes and their prevention, considerably broadened now with the addition of 28 diseases of penaeid shrimps. It is very well illustrated with many photos and photomicrographs needed in identifying disease problems.

Included are contributions from 22 experts which cover the diseases of cultured marine crustaceans, mollusks, finfishes, and turtles. In addition another chapter is devoted to chemotherapy, vaccines and disease resistance, and disease problems created by introduced species. Each chapter presents specific additional references; a basic list of general disease references is presented as Appendix I. Appendix II lists chemotherapeutants for marine aquaculturists.

For each disease is given the common name (and synonyms), species affected are listed, as is the cause of the disease, gross symptoms, and method of diagnosis. Also given are the life history, biology, and epizootiology, along with the effects on the host, treatment, preventive measures, and the known geographic distribution of the disease and, finally, key references on it.

The volume is an excellent handbook to the diseases problems in North American mariculture and an excellent reference for aquaculturists, students and others wherever these disases occur around the world. The first edition of this book was published in 1977 and in this edition, much has been rewritten and much has been added, making it even more useful. Hardbound, the 431-page volume is available from the publisher at Dfl. 200.00 or, in the United States, from Elsevier at P.O. Box 1663, Grand Central Station, New York, NY 10163 for $105.25.

Also published by Elsevier as volume 18 in the same series is "**Basic Fishery Science Programs**," subtitled "A Compendium of Microcomputer Programs and Manual of Operation," by Saul B. Saila, Conrad W. Recksiek, and Michael H. Prager. Saila is with the University of Rhode Island's Graduate School of Oceanography, Recksiek is with the URI Department of Fisheries, Aquaculture, and Pathology, and Prager is with the Department of Oceanography, Old Dominion University, Norfolk, VA.

Essentially, the volume is a compendium of computerized procedures, often unique to fishery science that will have widespread application for those with access to computers. Introductory chapters provide an overview of the author's FSAS (Fishery Science Applications System) system and its components, plus a tutorial on data entry, data editing, and the use of a typical application program. Additional chapters then summarize each application program, describing the analyses it performs and providing citations to pertinent fisheries literature. The computer programs described were written in the Microsoft implementation of the BASIC interpreted programming language BASICA (or GW BASIC) under the MS-DOS operating system. In addition, the authors discuss existing literature on computer applications in fisheries and suggest additional sources of information and software.

Section 2 describes the FSAS System, explaining its design and operations, system use and capabilities, and giving an FSAS tutorial, consisting of screen displays and a detailed description of each display that the user would see when using the FSAS. Also explained is the use of a spreadsheet with the FSAS.

Section 3 then gets into FSAS application programs, such as FISHPARM, a program for estimating the parameters of common fishery models by nonlinear least squares; BIREG, bivariate regression analyses; SEGREG, segmented linear regression analysis, and others. The authors have also made an effort to make their volume useful for solving problems in developing-nation fisheries. Each application program is summarized, and the analyses it performs are described, and the book should be very useful to fishries workers with access to a personal computer. Indexed, the hardbound volume is available from the publisher for US$73.75 or Dfl. 140.00.

The Migration of Fishes From Fresh to Salt Water

Publication of "**Diadromy in Fishes, Migrations Between Freshwater and Marine Environments**" by R. M. McDowall has been announced by Timber Press, 9999 S.W. Wilshire, Portland, Oregon 97225. The author is manager of the Freshwater Fisheries Center, Ministry of Agriculture and Fisheries, New Zealand. The book differs somewhat from other general volumes on fish migrations in being a review of anadromy, catadromy, and marine and freshwater amphidromy.

Initial chapters discuss the early beliefs and studies of diadromy and review the terminology involved, as well as the taxonomic extent of diadromy. Another chapter discusses geographical variations in diadromy and the origin and evolution of diadromy. Then follow detailed analyses of each of the three forms of migration by family grouping.

With some groups of fishes, diadromy is a strong, important part of their life history strategy (i.e., certain lampreys, eels, sturgeons, salmon, etc). For other groups, diadromy is a rarity. The author has provided a good synthesis of the knowledge on the subject and discussion of diadromy for some southern hemisphere species adds to the review.

Other chapters discuss diadromy as an adaptive life history strategy and the phenomenon of landlocking where a diadromous population becomes an exclusively freshwater population. Another, from the author's southern hemisphere perspective, examines the "transportability" of diadromy when such migratory species are transplanted, and the successes and failures with the transplants and reasons therefore.

Fisheries for diadromous species are also reviewed, group by group, as are distance and persistence in diadromous migrations. Also presented is the status of various diadromous fishes—i.e., which ones are rare, endangered, declining, extinct, vulnerable, of indeterminate status, or are of regional concern.

The book is a good review of diadromy and its scope and significance in fish behavior and ecology. It includes a lengthy bibliography and an appendix listing the diadromous fish species according to type of diadromy and latitudinal range. Indexed, the 308 page volume is available from the publisher for $47.95 plus $3 postage.

A Manual on Safety at the Seashore

"**Exploring Nature Safely**" by Ed Arrigoni has been published by Nature Safety Consultants, P.O. Box 22696, Honolulu, HI 96822. And while the manual seems aimed at professors or school teachers or youth group leaders, it presents considerable information of use to biologists or others who either chaperone, lead, or otherwise deal with citizen groups on field trips to their facilities or the seashore. Indeed, much of the information in the book addresses safety aspects in the seashore/marine environment. Another aspect of the book teaches how to study such areas without damaging the environment.

Chapter 1, "Starting Out," presents considerable information on how to plan and execute a safe outing, warning of many unsafe conditions or potential dangers that may face a group field trip. Another chapter deals specifically with outings on land, while the next reviews safety in the water environment—primarily marine, though it discusses safety along rivers and lakes too. Another chapter warns of hazardous plants and animals, including dangerous sea creatures. Color plates help illustrate many such hazardous creatures. Appendix A reviews first aid considerations, including measures to take if poisoned by various marine species. Appendix B lists other useful sources of information. Indexed, the 256-page paperbound volume would be a fine handbook for those who visit marine environments with groups for either education or pleasure. It presents a lot of cautionary material that many other outdoor safety/survival volumes ignore or overlook, but which are well worth remembering.

A Detailed Review of Fish Nutrition

"**Nutrition of Pond Fishes**" by Balfour Hepher has been published by the Cambridge University Press, 32 East 57th Street, New York, NY 10022. The late Dr. Hepher was formerly director of the Fish and Aquaculture Research Station, Dor, Israel, and had nearly a 40-year career in the field of aquaculture, during which he pioneered some of the important concepts of fish nutrition. Rather than a practical guide, the volume is a scholarly review of fish nutrition, utilizing a multidisciplinary approach to present a comprehensive account for students and scientists.

The book is presented in two parts. Part I thoroughly reviews food requirements, starting with the balance of energy—determining the food ration—and looking at the rudiments of food ingestion, the digestive process, and absorption of foods, factors affecting digestibility, and the various digestive enzymes, gastrointestinal flora, etc. Likewise reviewed are the energy pathways—the metabolism of carbohydrates, lipids, and proteins. Other chapters look at metabolism (how fish maintain life processes, the effects of water temperature, the energy costs of movement, and the utilization of metabolizable energy for maintenance) and growth (conditions affecting growth, potential growth rates, growth on reduced food rations and a summary of dietary energy requirements). Two other chapters examine the requirements of fish for protein and the sources of protein and the need for the other essential nutrients (i.e., essential fatty acids, vitamins, minerals, etc.), and the differing needs of various species for vitamins etc.

Part II examines the sources of fish foods and their utilization—natural foods and the estimation of their contribution or consumption and their composition. Likewise, supplemen-

tary feeds and their utilization are also reviewed and discussed, including types of supplemental feeds, feeding levels, feed composition, frequency of feeding, feed utilization, and feed conversion ratios. Appendices list apparent digestibility of feed ingredients, essential amino acid composition of fish and feed ingredients, proximate analyses of natural food organisms, and feeding charts for various species. The book also includes more than 60 pages of references, a systematic index for fish, and a subject index. Hardbound, the 388-page reference volume is available from the publisher for $69.50.

Guaranteeing High Quality Seafood for the Consumer

Publication of "**Quality Assurance of Seafood**" by Carmine Gorga and Louis J. Ronsivalli under the AVI Books imprint has been announced by Van Nostrand Reinhold, 115 Fifth Avenue, New York, NY 10003. Gorga is a fisheries consultant and Ronsivalli, retired, was a director of the NMFS Gloucester Technological Laboratory in Massachusetts. The book is published in three parts: I, assurance of seafood supply; II, assurance of seafood quality; and 3, administration and economics of quality assurance.

The authors stress that seafood quality assurance is not the same as seafood quality control; the former is a guarantee, and they use this book to provide a step-by-step review and discussion of the attitudes and steps that need to be adopted to guarantee the ultimate arbiter—the consumer—high quality fresh fish and fillets (shellfish or such products as canned, pickled, cured, or dried fish are not addressed). The book is suited for a broad audience, and it explains the various procedures in terms easily understood by processors, fishermen, as well as market owners and the consumers.

Part 1 presents general information on the values of seafoods, strategies for assuring the seafood supply, and the role of the U.S. government in the process. Part 2 then goes into seafood quality—how it is defined and measured, and how, why, and how fast seafood quality deteriorates. Then the authors discuss how to assure high seafood quality, discussing the roles of the fishermen, processors, retailers, and the consumers. Chapters in part 3 then outline the planning, administration, and coordination needed to assure high quality seafoods as well as the economics and economic benefits therein. Appendices discuss fish lipids, effects of decreasing temperature on the physical state of water in fish tissue, importance of accurately measuring seafood quality, spoilage rates of seafood, and provide formulae for the determination of gross profit margins and some specific costs. Indexed, the 245-page hardbound volume is available from the publisher for $42.95.

Freshwater Fishes of the Southern U.S.

Publication of "**Fishes of Arkansas**" by Henry W. Robison and Thomas M. Buchanan has been announced by The University of Arkansas Press, Fayetteville, AR 72701. This is an immense (536 pages), thorough, and scholarly volume, long in the making, and useful well beyond the boundaries of the State of Arkansas, at least in part owing to the number of fishes that traverse the Mississippi River and partly because most other Arkansas fishes have ranges well outside state borders. Indeed, with this volume and "Fishes of Wisconsin" one would have a fairly thorough coverage of central United States freshwater fishes.

Both authors have published extensively on Arkansas fishes and Robison, professor of biology at Southern Arkansas University, Magnolia, is coauthor of "The Fishes of Oklahoma." Buchanan, a professor of biology at Westark Community College at Fort Smith, is author of "Key to the Fishes of Arkansas."

The authors begin with a history of ichthyology in Arkansas, mentioning the role of Spencer F. Baird studying specimens collected by U.S. Army Capt. R. B. Marcy and sent back to the Smithsonian Institution, as well as other area collection efforts for the U.S. National Museum and the U.S. Fish Commission. Another chapter reviews the state's aquatic environment—the terrestrial and aquatic settings, environmental alterations, the rare, endangered, and introduced species, and its commercial fisheries.

Species accounts then make up the bulk of the book, with extensive data provided on the state's 215 species in 63 genera and 27 families (17 of the species have been introduced and one, the rainbow smelt, made its own way into Arkansas waters after having been introduced in northern states). The state's ichthyofauna is quite diverse, representing a little over 20 percent of the roughly 950 freshwater fishes in North America north of southern Mexico. The bulk of the 215 species are found in five families: 66 cyprinids, 41 percids, 20 centrarchids, 19 ictalurids, and 18 catostomids—more than 75 percent of the states fish species.

Economically, fishes are very important to the state as game, food, and bait: The state is the top-ranking producer of bait fish (a $20 million industry), and Arkansas ranks second to Mississippi in channel catfish production, at about $13 million. In 1985 alone, commercial fishermen harvested over 17 million pounds of wild fish worth $7.5 million.

Keys are provided to the families and to the species within each family. Data on each species includes general characteristics, life colors, variation and taxonomy, distribution, habitat, biology, data on their uses, if any, and how to distinguish them from similar species. Each species is well illustrated (often in color), and range maps depict their distribution in the state and in the nation, with a key for pre-1960 collections and 1960-87 collection records.

Appendices list scientific collections of Arkansas fishes, methods of preservation of fish specimens, aids to fish identification, and the fishes

known to occur in Arkansas. Also included is a glossary and an extensive literature cited section. Layout and design are excellent, and the volume is a fine encyclopedia of Arkansas fishes that would be useful to students, biologists, anglers, and others interested in the region's ichthyofauna. Hardbound, the 536 page volume is available from the publisher for $50 (cloth) or $30 (paper).

FISH CULTURE AROUND THE WORLD

Publication of "**Intensive Fish Farming**," edited by Jonathan Shepherd and Niall Bromage has been announced by Blackwell Scientific Publications, Inc., P.O. Box 50009, Palo Alto, CA 94303. Shepherd, former deputy director of the Institute of Aquaculture in Scotland is managing director of a Spanish aquaculture firm; Bromage is with the Institute of Aquaculture, University of Stirling, Scotland, and their book provides an authoritative review of current fish farming methods. The title term "intensive" separates the methods used for such species as channel catfish, trout, salmon, and yellowtail from the "extensive" means which, they say, relies more on art than science. Intensively farmed fish, they clarify, are "bred, reared and harvested within purpose-built facilities at high stocking densities" where the farmer uses mainly formulated diets and good husbandry instead of just fertilizers to improve nutrition in very large fish ponds.

Successful examples are reviewed in specific chapters on intensive marine farming in Japan by Takeshi Watanabe, fish culture in the United States by Nick Parker, and the development of polyculture in Israel by Shmuel Sharig. Watanabe's chapter discusses the culture of such species as red seabream, *Pagrus major*; yellowtail, *Seriola quinqueradiata*; and Japanese flounder, *Paralichthys olivaceus*, including broodstock maintenance, spawning, larval rearing, feeding schedules, growth, and production. Parker reviews culture of channel catfish, trout, salmon, striped bass (and hybrids), baitfish, tropical fish, and exotic species such as the various carps and tilapias. Sharig has reviewed the progression of fish culture in Israel from carp monoculture and polyculture with different size groups of carp, carp and mullet, tilapias, and using as many as 3-5 different species, into more intensive culture systems utilizing pond aeration, automatic feeders, higher stocking rates, etc., and adapting fish ponds for use for irrigation storage and merging them into the overall farm water scheme.

Initial chapters lead the reader through a general discussion of fish farming, the environmental requirements of fish and farm site evaluation, fish farming systems and culture practices, propagation and stock improvement, fish nutrition and growth, and fish health and disease. Overall, the book provides a good review of intensive fish farming practices and the factors that either aid or detract from their success, and it would be useful for students and others interested in these up-to-date and proven methods of fish culture.

One appendix provides an economic case study of Atlantic salmon farming; another lists useful information, i.e., aquaculture journals and related periodicals and scientific and common names of farmed fishes. Indexed, the hardbound 404-page volume is available from the publisher.

Asian Fisheries Society Produces New Journal

A new scientific journal, *Asian Fisheries Science*, has been initiated by the Asian Fisheries Society, MC P.O. Box 1501, Makati, Metro Manila, Philippines and is edited by J. L. Maclean, who reports that it is the first such regional journal dealing with fisheries and aquaculture research. The geographical scope of the new publication is the Indo-Pacific faunal zone, and it will feature studies and research activity in the various institutions and nations within that region. The institutional price is US$25 per volume (two issues), and one volume per year is scheduled. Airmail is $8 extra per volume. Individual subscriptions cost $12 per volume or $9 for Society members. The initial volume ran 106 pages and carried nine articles on topics ranging from the effects of eyestalk ablation on molting, growth, reproduction, and energy budget of *Macrobrachium nobilii*; leguiminous seeds as protein sources for milkfish, and maintenance of genetic quality in cultured tilapia, to parasites of wild and diseased young cultured golden snappers in Malaysia, aspects of reproductive biology of stolephorid anchovies in Papua New Guinea, and experimental culture of *Penaeus semisulcatus*, *P. brasiliensis* and *P. penicillatus* in Taiwan.

The Study of Marine Microbes

Publication of "**Marine Microbiology**" by B. Austin has been announced by Cambridge University Press, 32 East 57th Street, New York, NY 10022. The author is with the academic staff of Heriot-Watt University's Department of Brewing and Biological Sciences and has done specialized study at the Fish Diseases Laboratory in Weymouth, U.K.

This concise volume is aimed at providing undergraduate students with a background in marine microbiology, with emphasis on such newer aspects as biotechnology, fish and shellfish pathology, and deep-sea microbiology. It also introduces the habitats and ecology of marine microorganisms, their taxonomy, and pertinent microbiological techniques and methods, and it covers its topics very well and with a minimum of jargon.

Chapters specifically report microbiological methods, quantification of marine microbial populations, taxonomy of marine microorganisms and their ecology, microbiology of the macroorganisms and diseases of both

marine vertebrates and invertebrates, microbiology of the deep sea environment. Also discussed are useful aspects of marine microorganisms (biodegradation of pollutants, settling of invertebrate larvae, formation of managanese nodules, fermented food products) and problems (biodeterioration/biofouling of objects, mobilization of heavy metals, reservoirs for human pathogens, spoilage and food poisoning microorganisms in fish); and biotechnology (pharmaceutical compounds including antibiotics, antiviral compounds, antitumor compounds, enzymes, surfactants, and other potentially useful microbial products). Well written, the 222-page hardbound volume is available from the publisher for $59.50 (paperbound, $19.95).

ICLARM Reports Discuss Fish Research, Culture

"**Length-Based Methods in Fisheries Research**," edited by D. Pauly and G. R. Morgan has been copublished by the Kuwait Institute for Scientific Research and the International Center for Living Aquatic Resources Management (ICLARM), MC P.O. Box 1501, Makati, Metro Manila, Philippines. The volume constitutes the Proceedings of the International Conference on the Theory and Application of Length-Based Methods for Stock Assessment held 11-16 February 1985 in Mazzara del Vallo, Sicily, Italy.

Included are 22 papers from the conference, along with the reports of three of the four working groups formed during the conference, plus three contributions written immediately thereafter—chairman J. A. Gulland's overview, a review of programs discussed at the conference by the editors of the volume, and a note on some aspects of the problem of length-to-age vs. age-to-length conversion. The contributions review length-based methodologies for stock assessment of fish and aquatic invertebrates with particular reference to their precision and accuracy; review and test computer programs implementing length-based methods; and help identify the specific features of sampling schemes used to obtain length-frequency data for stock assessment. The 468-page hardbound volume includes author, geographic, and species indexes and is available from ICLARM as ICLARM Conference Proceedings 13 or, in the United States, from International Specialized Book Services, P.O. Box 1632, Beaverton, OR 97075 (price not listed).

ICLARM Conference Proceedings 14 is "**Detritus and Microbial Ecology in Aquaculture**," edited by D. J. W. Moriarty and R. S. V. Pullin. This presents the Proceedings of the Conference on Detrital Systems for Aquaculture held 26-31 August 1985 in Bellagio, Como, Italy. Contributions are grouped under session topics: Microbial ecology in aquaculture, production and characteristics of detritus, productivity and food chains, and manipulation of detrital systems for aquaculture. Also included is a conference consensus statement; general, genera and species, and geographic indexes; and a list of participants.

Individual articles discuss the use of manures, human wastes, and terrestrial vegetation and aquatic macrophytes in aquaculture; detrital and algal-based food chains in aquaculture; the role of meiofauna in marine detrital systems; composition and nutritive values of detritus; carbon pathways in aquatic detrital systems; production of organic fertilizers by composting; conversion of cellulosic and other organic wastes into microbial proteins; methods for determining biomass and productivity of microorganisms in detrital food webs; the role and impact of anaerobic microbial processes in aquatic systems; trophic dynamics of particle-bound bacteria in pelagic ecosystems, functional roles of the major groups of bacteria associated with detritus; and more. The 420-page paperbound volume is available either from ICLARM or from ISBS at $28.50, or, in Germany, from TRIOPS, Toeche-Mittler Distribution, Hindenburgstr. 33, 6100 Darmstadt, Frankfurt, FRG.

Practical Feeding of Farmed Fishes

Publication of "**Nutrition and Feeding of Fish**" by Tom Lovell and others has been published as an AVI imprint by Van Nostrand Reinhold, 115 Fifth Avenue, New York, NY 10003. Some specific chapters are written by experts in the field of nutrition for the particular species involved.

Following a review of the basic concepts of feeding fishes, Lovell reviews energy requirements and sources and necessary nutrients—proteins and amino acids, vitamins, essential lipids, and minerals, along with such nonnutrient diet components as toxins and anti-metabolites, diet additives, and accidental contaminants. Also discussed is fish digestion and metabolism, measuring nutrient digestibility in fish, and the rate of metabolism (oxygen consumption) in fish. Two additional chapters address feed formulation—ingredients and processing—and the use of fish feeding experiments.

Then comes the "meat" of the book, the practical chapters on feeding of the following fishes: Channel catfish by Lovell, tilapias by Chhorn Lim, salmon and trout by NMFS scientist Ronald W. Hardy, penaeid shrimps by Lim and Amber Persyn, eels by Shigeru Arai, and crawfish by Edwin H. Robinson. Each of these chapters review the species' nutritional requirements, feeding practices, the various feeds available, feeding rates and methods, etc. Where appropriate, the utilization of natural feeds is discussed. Appendices list composition of fish feed ingredients and the common and scientific names of species fish involved.

This is a very practical and useful book for aquaculturists and students and would also likely be of interest to those involved in fish food formulation and in setting up studies of fish feeding experiments. Indexed, the 260-page

hardbound book is available from the publisher for $46.95.

International Marine Policy

The potential for conflict and cooperation in marine affairs between and among the developed and developing nations is the general theme for "**North-South Perspectives on Marine Policy**," edited by Michael A. Morris, professor of Political Science at Clemson University, and published in the Special Studies in Ocean Science and Policy Series by Westview Press, 5500 Central Avenue, Boulder, CO 80301. Marine fisheries development can be vital to less developed island-nations and this volume views aspects of such issues in relation to overall marine policy, which includes sea-bed resouces, marine pollution, navigation rights, military policy, and more.

The volume is divided into three parts, with Part 1 presenting perspectives of developed nations, Part 2 the perspectives of the developing nations, while papers in Part 3 deal with aspects of North-South marine interactions. One paper in part 2, "Optimal Development of Third World Fisheries" by Conner Bailey deals very specifically with marine fisheries matters. Several other contributions include aspects of fisheries in discussions of other marine resources and issues. Major aspects of the contributions are then synthesized in a concluding chapter by the editor. Paperbound, the 267-page volume is available from the publisher for $28.50.

Price Correction for Northwest Coastal Fishes

The price listed ($29.95) for the book "Coastal Fishes of the Pacific Northwest" by Lamb and Edgell, published by Harbour Publishing Co., Ltd., P.O. Box 219, Madeira Park, B.C., Can., V0N 2H0 in 50(s) was incorrect. The correct price in the United States is $14.95 and in Canada it is $16.95.

Editorial Guidelines for the *Marine Fisheries Review*

The *Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under a completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, the *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Cited

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, and the year, month, volume, and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8 × 10 inches, sharply focused glossies of strong contrast. Potential cover photos are welcome, but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 50 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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